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Stimulation of storage tissues of higher plants by zinc sulphate

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The fact that chemical poisons under certain conditions and in certain quantities are of a stimulating nature to plants has been well established through the work of Raulin, Richards, Ono, Yashudi, Latham, Watterson, and others. A complete list of the references on the work done in this field may be found in the papers by M. E. Latham * and A. Watterson.† These investigations, however, have been conducted chiefly upon lower plants and the seedlings of higher ones. Little has been done upon the mature forms of the higher plants, or upon their various parts and tissues. This article attempts to describe some investigations on the effect of zinc sulphate stimulation on the storage tissues of some of the higher plants.

The work was done in the botanical laboratory of Barnard College, Columbia University, during the years 1907 and 1908, under the direction of Dr. H. M. Richards, to whom the writer is deeply indebted for his kind interest and assistance.

The investigation was in two parts, — first, the effect of solutions of zinc sulphate of various strengths upon the formation of periderm and callus, and second, the effect of such solutions upon the respiration of the tissue.

All zinc sulphate solutions weaker than normal were made up

* Latham, M. E. Stimulation of *Sterigmatocystis* by chloroform. Bull. Torrey Club **32**: 337. 1905.

† Watterson, A. The effect of chemical irritation on the respiration of fungi. Bull. Torrey Club **31**: 291. 1904.

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from a normal solution, prepared as follows: The zinc sulphate used was Merck's "highest purity reagent." For 100 c.c. of a normal solution, 14.3786 gm. of $ZnSo_4$ would be theoretically required (allowing $7H_2O$ for water of crystallization). 14.51923 gm. were weighed out, this differing from the required by 0.14063 gm. 14.3786 : 100 :: 0.14063 : x. $X = 0.978$ c.c. of water. Therefore, 100.978 c.c. of water added to 14.51923 gm. of zinc sulphate makes a normal solution. The water was the distilled water used in the laboratory. This was used also for washing all apparatus.

The apparatus used, and the results obtained in regard to the first part of the work, that is, the effect upon the periderm and callus formation, will first be described.

The glass dishes into which the specimens were to be placed, after being washed in distilled water, were put in the steam sterilizer, and heated at boiling point for not less than thirty minutes. The first experiments were made in an atmosphere dried by having a solution of potassium hydrate present in a small open dish. But the specimens dried out too much and were unsatisfactory for examination. Thereafter the experiments were conducted in a saturated atmosphere, the dishes being prepared in the following manner. All glassware was washed as stated above before using. The bottom of a glass dish was covered about a half or three quarters of an inch deep with very moist sphagnum. Then a side of a Petri plate which fitted closely into the glass dish was placed on the sphagnum. Then another glass dish slightly larger than the first was placed over it, forming a closely fitting cover. After heating in the steam sterilizer as aforesaid and cooling, the cover was lifted as little as possible at the side, and the specimens placed in an upright position on the Petri plate (see FIGURE 1, *a*). The covers of the dishes were never taken completely off during the experiments. They were always plainly labeled with the strength of the solution into which the specimens had been dipped, and the date the experiment was started, so no errors could arise through confusing the dishes — for example, "N/12 $ZnSO_4$, Jan. 23/09." The dishes for the control and the poisoned specimens were always prepared at the same time and in exactly the same manner. In some cases where it was thought possible that a variation in results was due to a difference in the atmosphere in the two dishes, the

experiment was repeated, placing both the control and the poisoned specimens in the same dish.

For cutting the tissues a copper tube was first used. Then a silver tube was substituted, as it was thought that the copper might have some effect upon the tissue with which it came in contact. But on comparing results, it appeared that the copper had had no effect upon the tissue. The tube, and the scalpel and forceps used in handling the specimens, were always placed in boiling water for a few minutes before each time they were used. The poisoned specimens and the control specimens were always taken from the same plant and were prepared in the following way: The potato, kohl-rabi, or whatever plant was used, was thoroughly washed and dried. Then the silver tube was pushed through the fleshy part of the plant root or tuber, and the cylinder thus cut was pushed out onto a piece of clean filter-paper. It was then usually cut into pieces 20 mm. long,—the tube was 7 mm. in diameter. The part closer than 3 or 4 mm. to the end was never used. In the cases of the roots, where there was a longitudinal axis, the pieces were cut with the longitudinal axis. This was repeated until a sufficient number of pieces of each plant was cut.

FIGURE 1. *a*, Diagram showing the manner in which the cylinders of tissue were placed in the culture dishes; *b*, diagram showing arrangement for collecting CO_2 given off for relatively short periods from small portions of tissue. The liquid in the dish is mercury.

Three pieces of each kind successively were put into a small bottle containing the zinc sulphate solution of required strength; and the same number was put into a like bottle containing distilled water. This was done in order that all factors of moisture, etc.—except that of the poison—might be as nearly the same as possible. After being left in the solution, or the water, for two or three minutes, the pieces were taken out with forceps, rolled upon

clean filter paper, and placed in the glass dishes previously prepared.

Examination to determine results was made by cutting sections of the cylindrical specimens, always about 5 mm. from the end. The sections were mounted in water and examined immediately after mounting.

PART I

Before making any experiments with zinc sulphate, several kinds of tissue were tested for their power to produce callus and meristem under the conditions to be used for the control. It was found that *Allium Cepa* (onion) could not be used because it decayed in the moist atmosphere. *Radicula Armoracia* (horse-radish) formed a suberized layer with meristematic tissue inside it, but was so susceptible to moulds that its use was abandoned. During the course of the experiments, *Brassica Rapa* (turnip) was tried, but it, too, proved unsatisfactory, because it was too easily affected by moulds and rot. *Helianthus tuberosus* (Jerusalem artichoke) was experimented with at the same time, but did not give the desired response. *Daucus Carota* (carrot) formed callus but so very slowly that it was considered unfavorable for experimentation. After this process of elimination, those which at first appeared to lend themselves favorably to the work in hand were *Beta vulgaris* (beet), *Ipomæa Batatas* (sweet potato), *Brassica oleracea* (kohl-rabi), *Solanum tuberosum* (potato), and, later, *Tragopogon porrifolius* (salsify). Of these the potato was quite the most satisfactory.

The sweet potato, which formed callus very readily at first, proved to be very suspectible to rot. It was probably due partially to this that the results obtained were so variable that they could not be used as a basis for any conclusions.

The beet, also, which seemed very desirable in the preliminary tests, did not form callus so readily after the experiments had been in progress for a few weeks, but dried out so much as to be useless for examination. When this trouble was encountered, freshly grown Bermuda beets were secured, but they gave no better satisfaction than the old ones. The results that were obtained, as in the case of the sweet potato, were so variable that no conclusions

could be drawn with regard to them. The variability in the results, in this instance, was largely due to the presence of vascular bundles running through the pieces used for experimentation.

The presence of the vascular bundles also confused, somewhat, the results obtained from salsify. In four cases out of seven, however, when the control pieces and the poisoned pieces were cut as

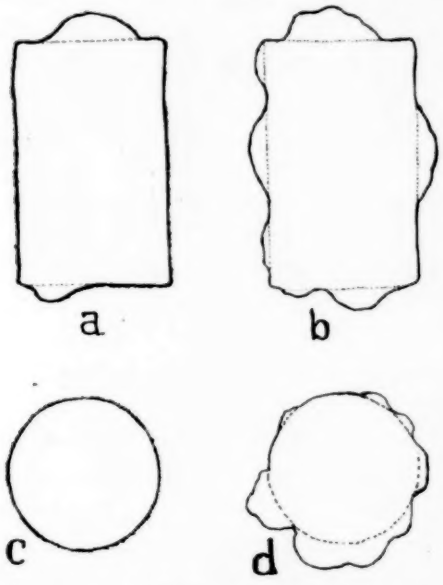

FIGURE 2. Transverse and longitudinal sections of cylinders of tissue from "kohl-rabi" for comparison of extent of callus formation with and without stimulation by zinc sulphate. *a* and *c* are the control specimens; *b* and *d* were stimulated with N/12 zinc sulphate. The drawings represent the condition two weeks after cutting, the stimulated specimens having been treated at once after the cylinders of tissue had been removed. Magnified 3 diam.

nearly alike as it was possible to make them, and always taken from the same plant, the specimens dipped in twelfth- and fourteenth-normal zinc sulphate solutions showed a greater formation of callus than the control specimens. In the other three experiments, the stimulated specimens formed less callus than the control specimens. In one of these three experiments, however, more meristem had formed in the poisoned piece than in the control.

In the experiments with the kohl-rabi, the same precautions were taken as with salsify, because of the presence of bundles.

Nevertheless, this was one factor which made the callus formation irregular, although it does not fully account for the fact that in most instances the callus formed in clumps, instead of making a uniform covering over the entire surface of the specimen. For this reason the observations on the gross appearance were thought to be of greater significance than any microscopical observations made on the specimens would be. In regard to the formation of meristem beneath the surface, none at all was formed in many experiments, even when callus was abundantly present. Its formation seemed to be dependent somewhat upon the age of the plant, and was too variable to furnish a basis for any conclusion. In regard

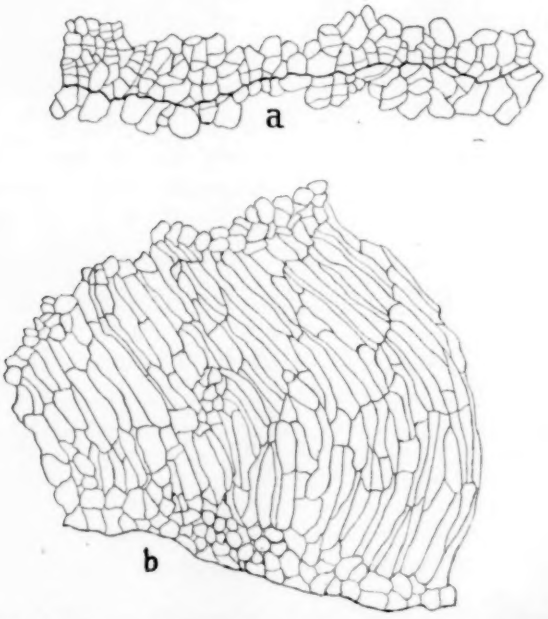

FIGURE 3. Sections of stimulated and unstimulated tissue of "kohl-rabi," cut vertically to the surface. Two weeks after setting up experiment; *a*, showing the callus formation as it appears pretty evenly all over the surface of the tissue, in the control; *b*, showing the callus formation in tissue stimulated with N/12 zinc sulphate, which is more irregular in its formation. See FIGURE 2. Magnified 38 diam.

to the callus, observations were taken upon twelve experiments using solutions of zinc sulphate from tenth to twentieth normal. In six of the experiments, the specimens poisoned with twelfth- and fourteenth-normal solutions formed callus more quickly than the

control, but irregularly and in large masses (see FIGURE 3). These pieces were also more susceptible to attacks of bacteria and moulds than were the control. In the control pieces callus was formed more slowly, but in a uniform layer over the entire surface of the specimen (see FIGURE 2). In two cases, the control had more callus formed than the poisoned pieces. In the other four experiments the results varied on the different occasions when the specimens were examined, making them valueless. Solutions stronger than tenth or twelfth normal inhibited the formation of callus. Those weaker than fourteenth normal, seemed to have little, if any, effect upon the callus formation.

Since the results in the formation of meristem in the potato were, by far, the most constant and satisfactory, the experiments on the potato will be described in detail:

EXPERIMENT I. Normal and half-normal solutions of zinc sulphate were used.

After four days:

Control. — One row of meristematic cells formed beneath the dried exterior.

N. — No meristem.

N/2. — No meristem.

After seven days:

Control. — A well-defined layer of meristem.

N. — No meristem.

N/2. — A few scattered meristematic cells two or three rows of cells beneath the surface, which was deeper than the location of the meristem in the control.

After fifteen days:

Control. — A meristematic layer several cells in thickness.

N. — Looked as if it may have recovered from the poison about two days before, as there were a great many scattered meristematic cells.

N/2. — A distinct layer of meristem a little beneath the surface.

EXPERIMENT II. Fourth- and eighth-normal solutions of zinc sulphate were used in this experiment.

After four days:

Control. — A distinct meristematic layer forming.

N/4. — No meristem.

N/8. — A number of meristematic cells but not so many as in the control.

After ten days:

Control. — A great deal of meristem close under the dried exterior.

N/4. — A good deal of meristem but not so much or so close to the exterior as in the control.

N/8. — Nearly as much as in the control. Also close to the exterior.

After twenty-one days:

Control. — A very thick layer of meristem.

N/4. — A great deal of meristem but not so much as in the control.

N/8. — Layer of meristem varies in thickness. Sometimes about the same as in the specimen poisoned with N/4 $ZnSO_4$ and sometimes nearly as thick as in the control.

EXPERIMENT III. Tenth- and twelfth-normal solutions of zinc sulphate were used.

After six days:

Control. — One row of cells meristematic.

N/10. — Almost the same as in the control.

N/12. — More meristem than in the control.

After fourteen days:

Control. — Outer meristematic cells dried and new layer forming within.

N/10. — About the same as in the control.

N/12. — Much heavier meristematic layer than in the control. (See FIGURE 4.)

EXPERIMENT IV. Twelfth- and fourteenth-normal solutions were used.

After five days:

Control. — Fairly thick layer of meristem.

N/12. — A little more meristem than in the control.

N/14. — More meristem than in the control — about the same as in the specimen stimulated with N/12 $ZnSO_4$.

After twelve days:

Control. — Heavy layer of meristem.

N/12. — About the same as in the control — impossible to say definitely whether there is more or less meristem formed.

N/14. — About the same as in the other two specimens.

After twenty-one days:

Control. — Exposed tissue dried to the edge of the meristematic layer, and some new meristem forming inside the first layer.

N/12. — Quite a little more meristem than in the control.

N/14. — About the same amount as in the specimens poisoned with N/12 $ZnSO_4$.

In view of these results it seems fair to make the following conclusions. Twelfth- and fourteenth-normal solutions of zinc sulphate stimulate the formation of meristematic tissue in the potato. A tenth-normal solution neither stimulates nor inhibits the forma-

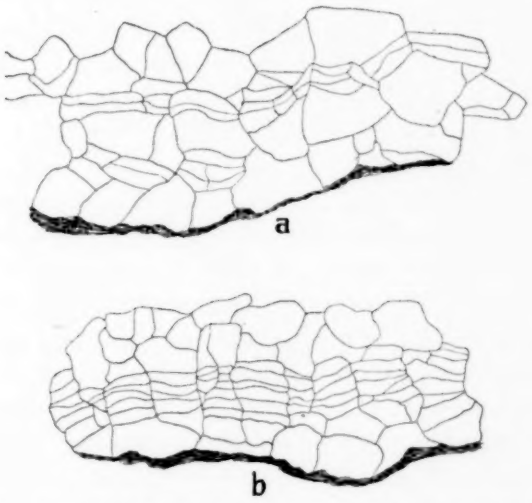

FIGURE 4. Section of stimulated and unstimulated tissue of potato tuber, cut vertically to surface. Three weeks after setting up experiment; *a*, showing the callus formation in control specimen; *b*, showing callus formation in tissue subjected to the stimulus of N/12 zinc sulphate. Magnified 53 diam.

tion of meristem. The tissue recovers from the effects of eighth-normal solution in about three or four days, from fourth-normal solution in eight or ten days, from half-normal solution in about seven days, and from the normal solution in from thirteen to fifteen days. Owing to the method by which the solutions must necessarily be applied, it is, of course, impossible to determine definitely

the exact concentration of zinc sulphate which reaches the cell. In this method, however, the critical or optimum point of concentration for this tissue is the twelfth and fourteenth normal.

PART II

In the second part of the work, the object was to determine the effect of the zinc sulphate stimulation upon the respiration of the storage tissue. Since the results with the potato in the foregoing experiments were the most nearly constant, it was the only tissue used in these latter experiments. The pieces were prepared in exactly the same manner as those used in Part I. They were then put into flasks which had been previously prepared in the following manner: The flask was weighed, then filled with distilled water, and weighed again. The first weight was subtracted from the second, the remainder being the number of grams of water the flask contained, or the volume of the flask in cubic centimeters (1 gm. H_2O = 1 c.c.). The three flasks used were always labeled I., II., and III. The volume of flask I. was 94.093 c.c.; the volume of flask II., 90.506 c.c., and that of flask III., 105.433 c.c. Flask I. was always used for the control. Before using, the flasks were always thoroughly washed in tap water, then rinsed three times in distilled water, and allowed to dry over night in an inverted position. Whenever it was necessary to use them again on the same day they were washed, they were dried in a drying oven at 100° C.

In the first experiment ten pieces of potato were used; in the second, fifteen; and in all the following experiments, twelve. After the pieces had been dipped and rolled on filter paper, they were put into the respective flasks, and cotton stoppers were inserted in the mouths of the flasks, which were then inverted over mercury cups (see FIGURE 1, *b*).

For analyzing the gas the Bonnier-Mangin instrument for gas analysis was used. In transferring the flasks from the mercury cup to the Bonnier-Mangin apparatus, a moistened finger tip was always held over the mouth of the flask until it was inserted in the mercury cup of the gas-analyzer. Before inserting it in the cup, the pieces in the flask were always shaken about a little to make sure that the gas in the flask would be uniform in composition.

The gas in every flask was analyzed twice and the average of the two results taken. Between each analysis hydrochloric acid was run in to remove all traces of the potassium hydroxide, after which the apparatus was rinsed three times with distilled water.

Stimulated				Control		Diff. in c.c. of CO_2 in control and stimulated. + = control more — = control less
Strength of $ZnSO_4$ sol.	Original per cent. of CO_2	Per cent. of CO_2 corrected for vol. of flask	Actual amount of CO_2 in c.c.	Original per cent. of CO_2	Actual amount of CO_2 in c.c.	
$\frac{N}{2}$	12.01	11.46	9.46	16.93	15.93	+ 6.47
	7.61	7.27	6.29	12.63	11.89	+ 5.60
$\frac{N}{12}$	12.40	11.84	10.05	13.48	12.68	+ 2.63
	10.41	9.94	8.44	10.67	10.14	+ 1.70
	8.59	8.21	6.97	9.52	8.96	+ 1.99
$\frac{N}{14}$	16.35	15.64	13.25	16.67	15.69	+ 2.44
	16.90	19.15	16.26	16.67	15.69	— 0.57
$\frac{N}{16}$	17.87	20.26	17.19	15.44	14.53	— 2.66
	17.80	20.18	17.13	17.54	16.50	— 0.63
	16.90	19.18	16.27	16.11	15.16	— 1.11
$\frac{N}{24}$	16.12	15.43	13.07	16.11	15.16	+ 2.09
	18.50	17.67	15.00	21.03	19.79	+ 4.79
$\frac{N}{32}$	18.14	17.33	14.71	17.54	16.50	+ 1.79
	20.96	23.76	20.16	21.03	19.79	— 0.37

It may be of interest to describe the method of analysis and the method of calculating results. A sample of gas was drawn into the tube of the apparatus and measured. It measured, for example, 51.10 c.mm., the correction having been made for the water present in the tube. Then a ten per cent. solution of potassium hydroxide was drawn in, run back and forth in the tube several times, and the remaining gas measured. In this case it was 43.05 c.mm., the difference between the two amounts, 8.05 c.mm., or 15.75 per cent., being the amount of carbon dioxide present in the sample. In the next analysis, 16.5 per cent. was the result gotten, the average being 16.125 per cent. This experiment was performed in flask II., the volume of which was 90.306 c.c. But 9.236 c.c. of the flask was occupied by the twelve pieces of potato 20 mm. long and 7 mm. in diameter. Therefore the complete amount of gas present in the flask was 81.07 c.c., 16.125 per cent. of which, or 13.072 c.c., was carbon dioxide. The volume of the

control flask was 94.093 c.c. Subtracting the bulk of potato, the volume of gas present would be 84.857 c.c. If 13.072 c.c. of the total gas volume, 84.857 c.c., was carbon dioxide, the per cent. of carbon dioxide present would be 15.43. This is an example of the method used in all the analyses and calculations, the results of which will be found on page 499.

These investigations are merely the introduction to what might be done in the way of experiments showing the effect of zinc sulphate stimulations upon the respiration of storage tissues, but they serve to indicate that fourteenth-normal solutions, or any solutions stronger than that, inhibit the respiration of the storage tissue of potato. A sixteenth-normal solution stimulates respiration. Further than that, the results so far obtained do not justify any definite statements. It is hoped that at some future time the data already obtained in these investigations may be amplified and the work carried on to a far greater extent.

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The Crataegi of Mexico and Central America

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In the autumn of 1905, Dr. C. G. Pringle sent me, from Mexico, fruiting material of what he considered a new species of *Crataegus*. Study of the literature of both the Mexican and the South American species satisfied me that he was correct in his diagnosis; but I asked him to get me flowering material from the same station. This he did in April, 1906, and *Crataegus Baroussana* was then described (Torreya **7**: 35). Since then I have seen specimens of this species, *J. Gregg 433*, "mountains near Saltillo, 1848 or 49," both in the herbarium of the Missouri Botanical Garden and in the Gray Herbarium. Dr. Pringle tells me that his *C. Baroussana* ravine overlooks the battlefield of Buena Vista and therefore his station might be Dr. Gregg's as well.

The study required for this species led me to a more extensive investigation of this group as it is represented south of the Mexican boundary. I had trouble in finding important literature; many of the types were in Europe; and all of the South American species were inaccessible to me. The literature has now all been secured and a good idea of most of the types obtained, but to find material of the South American species has been a harder proposition. There is but one sheet of a South American *Crataegus* in the great herbaria of the United States. This is a flowering specimen of *C. spinosa* DC. in the herbarium of the New York Botanical Garden.

Happily, most of the South American species can easily be eliminated from the problem by their descriptions. *C. stipulosa* (H.B.K.) Steud. and *C. quitensis* Benth. were the only ones that troubled me, and a flowering specimen (from the type locality) of *C. stipulosa* and a drawing of the type of Bentham's *C. quitensis* were very kindly sent me by Lt. Col. Prain, Director of the Royal Botanic Gardens, Kew.

Dr. C. G. Pringle and Dr. Edward Palmer have made special

trips in Mexico for me; and Dr. J. N. Rose, Mr. J. N. Painter, and Mr. W. R. Maxon, of the U. S. National Museum, and Mr. E. W. Nelson and Mr. E. A. Goldman of the U. S. Biological Survey have also given me information in regard to the Mexican species. In fact, without the recent work of these gentlemen in Mexico our knowledge would be very limited indeed. I have also had full access to the material in the Gray Herbarium, the National Museum, the Missouri Botanical Garden, and the Arnold Arboretum.

The first notice we have of *Crataegus* in Mexico was by Dr. F. Hernandez who resided in Mexico from about 1570 to 1580. His Nova Plantarum, Animalium et Mineralium Mexicanorum Historia was published at Rome in 1651, and his De Historia Plantarum Novae Hispaniae at Madrid in 1790.

The first definite work on the group was that of Mocino & Sessé (about the City of Mexico), but this work was not given to the world until De Candolle published the Pomaceae of his Prodomus in 1825. Baron von Humboldt found the rare *C. pubescens* (H.B.K.) Steud. in Real de Moran, Hidalgo, and published it in 1824. It seems remarkable that he should have picked up this rare and little-known species and not have observed the more common *C. mexicana* Moc. & Sessé. Around these two species and that of Bonpland's *C. stipulosa* (H.B.K.) Steud. from Ecuador, there has been a storm center ever since. One will find herbarium sheets about equally marked with these names, when as a matter of fact most of them are *C. mexicana* Moc. & Sessé.

Although the type of *Crataegus mexicana* Moc. & Sessé has not been seen, it is easy to settle the status of the species, for it was collected in the vicinity of the City of Mexico and the tracing of Mocino & Sessé's drawing is extant; this, with the fact that only one species is known near the City of Mexico seems to settle the status of *C. mexicana*. *C. stipulosa* (H.B.K.) Steud., as to description, matches very well with *C. mexicana*, but the flowering material sent from Kew seems different, and until *C. stipulosa* is well known it is better to hold to the name *C. mexicana*, although they may prove to be one species, in which case, *C. stipulosa*, being the older name, will replace the other. *C. pubescens* (H.B.K.) Steud. has been another stumbling-block. It was collected in

flower by Humboldt and is finely described and figured by Kunth in the Nova Genera et Species; but flowering material of closely allied species of *Crataegi* furnishes very unsatisfactory data for determination and should be reinforced by mature fruiting material whenever possible. Dr. Rose's Jalapa plant supplied immature fruiting material for me; and last fall, Dr. Pringle collected mature fruit at Honey Station, Hidalgo (this station is within a mile or two, at least, of Humboldt's locality, Real de Moran).

My purpose in this article is to describe the wild species of Mexico and Central America but my final treatment of the group will require also a good deal of notice given to the different forms raised in and described from the various European botanical gardens. I have no evidence that either *C. pubescens* or *C. stipulosa* has ever been cultivated in botanical gardens but in the early thirties *C. mexicana* (*C. stipulacea* Lodd.) was of much interest to the English gardeners and there was some controversy at the time in regard to when and by whom it was introduced. The evidence seems to point to the fact that it must have been received in England from two sources in 1824 or a few years before that (see Gard. Mag. **9**: 496, 630; **11**: 473, 583. — G. Don, Gen. Dict. **2**: 598. — D. Don, in Sweet, Brit. Flow. Gard. **6**: 300). From England it was introduced to the continent. It does not seem to have been raised in the United States, although it might easily be grown from Washington or St. Louis south. Of the garden species *C. lobata* Bosc, *C. grandiflora* Smith, *C. Carrierei* × Carrière, *C. Lavallei* Hérincq, and *C. grignoniensis* Mouillefert, I have seen fresh fruiting material of only *C. Lavallei;* this was sent me last fall from Segrez, France, by Mr. Lavallée and might well be a hybrid between *C. mexicana* and *C. Crus-galli*, as it has been called. The colored plates of this and *C. Carrierei* are much alike and seem to me to represent practically the same form. *C. grandiflora* Smith and *C. lobata* Bosc may be Mexican species or at least partially derived from them, but these are doubtful points, needing more careful investigation. However, I have not sufficient knowledge of these species as yet, having but recently seen some of the important literature on the subject.

The genus *Crataegus*, south of the United States, seems confined to the tablelands of Mexico and southward through the

highlands of the Andes. In Mexico the fruit is of much economic importance, being often found in the markets, and the trees are guarded as carefully as other fruit trees are with us.

Key to Mexican and Central American Crataegi in flower

1. Vegetative twigs, corymbs, and lower surface of leaves glabrous; leaves broadly ovate; stamens about 10; styles 4 or 5, calyx-lobes serrate; fruit red. ..... *C. Baroussana.*
1. Vegetative twigs, lower surface of leaves, and corymbs tomentose... 2.
2. Leaves broadly ovate, tomentose on both sides; stamens about 10; styles 4 or 5; calyx-lobes serrate; fruit red..... *C. Greggiana.*
2. Leaves narrower, — elliptical, lanceolate, etc..... 3.
3. Stamens 5–10; styles 3 or 4; calyx-lobes serrate; fruit red ..... *C. Rosei.*
3. Stamens about 20..... 4.
4. Calyx-lobes serrate, styles usually 2 or 3; fruit yellow. *C. pubescens.*
4. Calyx-lobes entire..... 5.
5. Leaves oblanceolate..... *C. stipulosa.*
5. Leaves lanceolate, elliptical, etc. ..... 6.
6. Styles 2–3; leaves glabrous above; fruit yellow..... *C. Parryana.*
6. Styles 3–5, leaves tomentose above..... 7.
7. Leaves 3–9 cm. long, styles usually 3 or 4; fruit orange..... *C. mexicana.*
7. Leaves 1.5–5 cm. long; styles usually 4 or 5..... *C. Nelsoni.*

Key to Mexican and Central American Crataegi in fruit

1. Vegetative twigs glabrous..... ..... *C. Baroussana*
1. Vegetative twigs tomentose..... ..... 2.
2. Leaves broadly ovate..... *C. Greggiana.*
2. Leaves elliptical, etc. ..... 3.
3. Fruit large, 15–30 mm. thick..... 4.
3. Fruit small, 8–15 mm. thick..... 5.
4. Leaves oblanceolate..... *C. stipulosa.*
4. Leaves lanceolate, etc..... 6.
6. Nutlets 3–5; calyx-lobes erect, entire; fruit orange..... *C. mexicana.*
6. Nutlets 2 or 3; calyx-lobes reflexed, glandular-serrate; fruit light yellow..... *C. pubescens.*
5. Nutlets 2 or 3; fruit yellow; calyx-lobes entire ..... *C. Parryana.*
5. Nutlets 3 or 4; fruit red; calyx-lobes serrate..... *C. Rosei.*
5. Nutlets 4 or 5; calyx-lobes entire ..... *C. Nelsoni.*

CRATAEGUS PUBESCENS (H.B.K.) Steud. Nom. Bot. 433. 1841 [ed. 2]

Mespilus pubescens H.B.K. Nov. Gen. et Sp. **6**: 213. *pl. 565.* 1824.

Leaves 1–7.5 cm. long, 0.8–4 cm. wide, rhomboid-elliptical to ovate or sometimes obovate or spatulate, often one-sided towards the base, serrate or crenate-serrate, often doubly so, with gland-tipped teeth, leaves of the vegetative shoots often three-lobed towards the apex and extremely variable as to size, acute at the apex, cuneate at base, subcoriaceous, slightly appressed-pubescent and impressed-veined above when young, bright green becoming nearly glabrous above when mature, paler and tomentose below; petioles 2–10 mm. long, slightly winged and pubescent; stipules falcate to half-ovate, strongly glandular-serrate, fugacious; corymbs 6–10-flowered, tomentose, flowers 10–12 mm. wide, the lanceolate acute strongly glandular-serrate calyx-lobes nearly glabrous; stamens about 20; styles usually 2 or 3, occasionally 4; fruit compressed-globose to globose, light straw-colored (according to Pringle), 15–25 mm. thick; calyx-lobes reflexed, mostly deciduous; flesh light yellow; nutlets 2–4, strongly ridged on the back, 8–10 mm. long, nest of nutlets 10–12 mm. thick. Young twigs slightly tomentose becoming glabrous, light chestnut-brown. Thorns 1–3 cm. long, slender, straight, frequent. Habit of the common apple tree, sometimes 10 m. high.

This species has been infrequently found in the moister region (1000–3000 m.) of the eastern border of the tableland, ranging from Hidalgo southwards.

Type locality, Real de Moran, State of Hidalgo (2420 m.), *Humboldt.*

Specimens examined:

Jalapa, Vera Cruz, *C. J. W. Schiede*, 1828. (Herb. Columbia Univ. and Gray Herb.)

Jalapa, *C. L. Smith 1484*, Apr. 11, 1894, 6900 ft. (Gray Herb.)

Jalapa, *C. G. Pringle 8081*, Mar. 30, 1899.

Jalapa, *J. N. Rose & W. Hough 4250*, May 17–22, 1899. (Herb. U. S. Nat. Museum and herb. N. Y. Bot. Gard.)

Honey Station, Hidalgo, *C. G. Pringle*, Oct. 22, 1908. (Herb. N. Y. Bot. Gard.)

The next number probably belongs to this species:

E. W. Nelson 1334, eighteen miles southwest of city of Oaxaca, Sept. 10–20, 1897. (Gray Herb. and herb. U. S. Nat. Mus.)

Crataegus pubescens Botterii var. nov.

Leaves shorter than those of the type, tomentose above, more rugose than in the type, densely white-tomentose; corymbs densely white-tomentose.

This may prove a distinct species when better known.

Type: *Botteri 1121*. (Gray Herb.)

Specimens examined:

Orizaba, *Botteri 1121*, about 1850. (Herb. U. S. Nat. Mus. and Gray Herb.)

Huatasco, Vera Cruz, *C. Mohr*, 1856. (Mohr Herb., U. S. Nat. Mus.)

Eugenio, Rincón de la Carbonera, Orizaba, *F. Müller*, 1853. (Herb. Columbia Univ.)

Boca del Monte, Orizaba, *E. W. Nelson 218*, May 13, 1894. (Herb. U. S. Nat. Mus.)

CRATAEGUS MEXICANA Moc. & Sessé; DC. Prod. **2**: 629. 1825. — Moc. & Sessé, Dessins Fl. Mex. *pl. 299*. 1874. — Bot. Reg. **22**: *pl. 1910*. 1836. — Loudon, Arb. et Frut. Brit. **2**: 843, 867; **6**: 156. 1838. — D. Don in Sweet, Brit. Flow. Gard. **6**: *pl. 300*. 1835

C. subserrata Benth. Plantae Hartweg. 10. 1839.

C. hypolasia K. Koch, Hort. Dend. 167. 1853.

Leaves elliptical-lanceolate or oblanceolate, 3–9 cm. long, 1.5–4 cm. wide, serrate-crenate, with gland-tipped teeth, sometimes slightly lobed towards the apex, often irregularly so or the margin repand, entire towards the base, obtuse or acute at the apex, cuneate at the base, dull, coriaceous, tomentose above, sometimes becoming nearly glabrous, impressed-veined and slightly corrugated; tomentose below, particularly along the veins; petioles 5–10 mm. long, slightly winged, tomentose; corymbs 4–10-flowered, densely white-tomentose; flowers 15–20 mm. wide; calyx-lobes less tomentose, about 6 mm. long, lanceolate, entire except at the apex, which is usually obtuse and often has two to four nearly equal gland-tipped teeth; stamens about 20, anthers pink, styles 3–5, densely tomentose about the base; fruit ovoid, short-ellipsoidal or short-pyriform, 15–25 mm. thick, edible, orange or rusty orange, calyx-lobes erect, thickened at the base;

nutlets 3–5, broadly ridged on the back, obtuse at the ends, 8–10 mm. long, nest of nutlets 10–12 mm. thick. A small tree sometimes 10 m. high, resembling the common apple tree in habit. Young twigs tomentose. Thorns often wanting or trees occasionally armed with short thorns.

A tree of the higher altitudes (1000–3000 m.) of the central tableland, ranging from central Mexico (San Luis Potosi, *Parry & Palmer 228*) southward.

Type station, vicinity of the City of Mexico, *Mocino & Sessé*.

Specimens examined:

C. G. Pringle 13736, Eslava, Federal District, Mexico, 7800 feet, Mar. 22, 1906. Tree 15–25 feet. Also fruit from this station, Nov. 7, 1907. (Herb. N. Y. Bot. Gard.)

C. G. Pringle 6547, base of Sierra de Ajusco, Federal District, Mexico, 7800 feet, Sept. 29, 1896.

C. G. Pringle 6631, river banks near Tula, Hidalgo, 6800 feet, June 15, 1897.

C. G. Pringle 6983, fields about Tepoxtlan, Morelos, Mexico, 7500 feet, Mar. 15, 1899. A large tree.

C. G. Pringle 11400, Eslava, State of Mexico, 8000 feet, Sept. 17, 1903.

C. G. Pringle 1467, Marquess, State of Mexico, 8000 feet, Apr. 20, 1887.

J. Gregg 618 and *618b*, valley and hills below Real del Monte, Mexico, 1848–49.

Graham, Mexico. (Gray Herb.)

Herb. de la Commission Scientifique du Méxique *50*. Santa Fé près México.

J. G. Schaffner Herb. San Luis Potosi, May, 1881. (Gray Herb.)

Parry & Palmer 228, San Luis Potosi, 1878.

E. Palmer, San Luis Potosi mountains, 1878.

Rose & Painter 7118, Eslava, Valley of Mexico, Sept. 17, 1903.

Rose & Painter 7894, Nevada de Toluca, State of Mexico, Oct. 15, 1903.

Rose, Painter, & Rose 9483 and *9484*, San Angel, Valley of Mexico, Aug. 15, 1905.

Rose & Hough 4532, near Tlalpam, Valley of Mexico, June 9, 1899.

Rose & Hough 4710, between Tepeaca and Santa Rosa, Pueblo, Mexico, June 27, 1899.

Rose & Hay 5293, near Dublan, Hidalgo, Mexico, July 2, 1901.

W. Trelease 40, above Malhalla, Vera Cruz, Mexico, Feb. 19, 1905.

C. subserrata Benth., *Hartweg 47*, Mexico, as seen in the Gray Herbarium, seems to represent a rather entire-leaved form of *C. mexicana*, which, as to the Gray Herbarium specimen, is not worthy of even a varietal name.

Crataegus mexicana microsperma var. nov.

C. pubescens Watson, Proc. Am. Acad. **22**: 396. 1887. Not *Mespilus pubescens* H. B. K.

Leaves narrower than those of the type; fruit pyriform, yellow, with red cheeks, 10–15 mm. thick; nutlets 3–5, about 6 mm. long, grooved on the back, with calyx-scar, nest of nutlets 7–8 mm. thick.

This may prove a good species.

Type, *E. Palmer 465*, Guadalajara, Jalisco, Mexico, Sept., 1886.

The following numbers also I would refer here:

E. W. Nelson 553, west slope of Mt. Zempoaltepec, Oaxaca, Mexico, 7700–8000 feet, July 5–13, 1894.

E. W. Nelson 4092, roadside between San Sebastian and the summit of the mountain known as the Bufa de Mascote, Jalisco, Mexico, 7200 feet, Mar. 20, 1897.

M. E. Jones 136, Chiquilistlan, Jalisco, Mexico, June 1, 1892.

I doubtfully refer the following numbers to this variety:

E. W. Nelson 6555, Patamban, Michoacan, Mexico, 6500–8500 feet, Jan. 27, 28, 1903.

E. Langlassé 45, Village du Durarno, Michoacan et Guerrero, Mexico, Mar. 20, 1899.

Of no. 465 Dr. Palmer says, "Twenty feet high; fruit yellow with black dots, and often a red blush on one side, Guadalajara; September (465). *Tejocote*, a jelly, is made from the fruit, resembling that from the quince."

CRATAEGUS STIPULOSA (H.B.K.) Steud. Nom. Bot. 433. 1841 [ed. 2]

Mespilus stipulosa H.B.K. Nov. Gen. et Sp. **6**: 213. 1824.

Material from Gautemala matches this species better than any other I have seen. The leaves are oblong or obovate-oblong,

tomentose, acute at the apex, cuneate at the base, crenate-serrate, tomentose; corymbs densely white-tomentose, few-flowered; stamens about 20; fruit globose or short-pyriform, (yellow?), 15–30 mm. thick, calyx deciduous; nutlets 2–4.

Specimens examined:

J. D. Smith 2531, Las Delicias, Depart. Sacatepéquez, Guatemala, 7000 feet, Mar. 1892.

Heyde & Lux 3324, Santa Rosa, Depart. Santa Rosa, Guatemala, 4000 feet, Apr. 1892.

W. A. Kellerman 7071, Volcano Agua, Depart. Sacatepéquez, Guatemala, 9000 feet, Feb. 4, 1908.

W. A. Kellerman 4529, Volcano Agua, Guatemala, Feb. 18, 1905.

Maxon & Hay 3668, Volcano Agua, Guatemala, 1800 m., Mar. 21, 1905.

W. R. Maxon, fruit bought in the market of Mazatenango, Guatemala, Feb. 1905.

The following I would refer to this species with some doubt:

E. W. Nelson 3162, near San Cristobal, Chiapas, Mexico, 7000–8800 feet, Sept. 18, 1895.

E. A. Goldman 941, Teopisca, Chiapas, Mexico, May 7, 1894.

Crataegus Rosei sp. nov.

Leaves short-spatulate to obovate, obtuse at the apex, cuneate at the base, serrate-creneate with fine teeth, slightly pubescent along the veins, finely rugose, shining, yellow-green above, paler and tomentose along the veins below; petioles 5–10 mm. long, slightly winged, pubescent, stipules of the vegetative twigs semilunate, 3–4 mm. long, glandular-serrate; corymbs 3–9-flowered, whitish-villose; flowers 12–15 mm. wide, calyx and lobes slightly villose, calyx-lobes remotely serrate or entire, lanceolate, acute, 2–3 mm. long; stamens 5–10; styles 2–4, surrounded at the base by a dense tuft of tomentum; fruit ellipsoidal or pyriform, red, 8–12 mm. thick, slightly villose, flesh soft, calyx-lobes reflexed or spreading, nutlets usually 3, strongly ridged on the back, 6–7 mm. long, nest of nutlets 8–9 mm. thick. Vegetative twigs villose, yellow-green, becoming glabrous and ash-gray, armed with chestnut-brown, slightly curved spines 2–4 cm. long.

Type *E. Palmer 74*, Alvarez, San Luis Potosi, Mexico, Sept. 5–10, 1902. (Herb. N. Y. Bot. Gard.).

Of no. 74 Dr. Palmer says, "*Tejocote colorado.* The fruits are

sold in San Luis Potosi for making *cayata*. A small tree; 15 feet may cover the height of the tallest. It has the habit of the hawthorn with an immense crop of fruit which is eaten raw by the people."

Of no. 47, "Small tree like the hawthorn of the United States, very thorny; the fruits are edible, very productive; of the general height of 10–15 feet, very bushy, known as *Tejocote;* the fruit hangs on the tree a long time."

Of no. 229, "*Tejocote*, one of the most useful trees found here, has a thick compact top of dark green leaves that have a fine polish, thus enabling it to stand dryness, is loaded with fruit. The wood is white, tough and durable, used for handles of tools; the fruits are of a red color, are eaten raw and made into preserves and jelly. Height 20–30 feet and diameter 6–15 inches, flowers white and sweet-scented, found in secluded nooks in ravines or by mountains near water-courses."

Specimens examined:

E. Palmer 74. (Herb. N. Y. Bot. Gard., Gray Herb., herb. U. S. Nat. Mus. and herb. Arn. Arbor.)

E. Palmer 47, Santiago Papasquiaro, Durango, Mexico, Apr., 1896. (Herb. N. Y. Bot. Gard., Gray Herb., herb. U. S. Nat. Mus., herb. Arn. Arbor.)

E. Palmer 229, Tobar, Durango, Mexico, May 28–31, 1909. (Herb. N. Y. Bot. Gard. and herb. U. S. Nat. Mus.)

E. Palmer 333, vicinity of Chihuahua, Mexico, June 5–10, 1908. (Herb. U. S. Nat. Mus. and herb. N. Y. Bot. Gard.)

E. W. Nelson 4673, Papasquiaro, Durango, Mexico, Aug. 7, 1898. (Herb. U. S. Nat. Mus.)

This species of the interior plateau seems to take the place of *C. mexicana* in northern Mexico. It will be surprising if it is not found in southern New Mexico and Arizona.

Crataegus Parryana sp. nov.

Leaves 1.5–4 cm. long, 1–3 cm. wide, oblong-rhomboidal to elliptical-ovate, serrate nearly to the base, sometimes doubly serrate, with gland-tipped teeth, coriaceous, bright yellow-green, glabrous, rugose, impressed-veined above, paler and strongly tomentose along the midrib below, acute at the apex, cuneate at the base; petioles 2–5 mm. long, slightly pubescent; corymbs few-flowered

(2–4-fruited), pedicels slightly whitish tomentose; fruit yellow, compressed-globose, 12–18 mm. thick, slightly pubescent; calyx-lobes appressed, lanceolate, acute, slightly tomentose; stamens about 20, tomentose about the base; nutlets 2 or 3, obtuse, strongly ridged on the back, 7–9 mm. long, nest of nutlets 8–10 mm. thick. Young twigs light chestnut-brown, slightly pubescent, becoming gray and glabrous. Thorns numerous, at first chestnut-brown, 2–4.5 cm. long, nearly straight. In habit like the apple or the hawthorn.

Type, *E. Palmer 75*, Alvarez, San Luis Potosi, Mexico, Sept. 5–10, 1902. (Herb. U. S. Nat. Mus.)

Of this number Dr. Palmer says. "*Tejocote ameco.* The fruit of this form is sometimes a little larger than no. 74 [*C. Rosei*], and if it can be a larger crop of fruit. Has a fine odor. A small tree; 15 feet may cover the height of the tallest. It has the habit of the hawthorn. Quite thorny. May not the cultivated yellow ones of San Luis Potosi originate here?" He also told me that the locality where he found this species and no. 74, in the mountains about twenty miles southeast of the city of San Luis Potosi, had the greatest number of individual trees of any place he had seen, and was also the only place that he would be sure that *Crataegus* was wild in Mexico.

Dr. Pringle, however, says that although *Crataegus* is frequently cultivated in the Mexican gardens, still a great many of the seemingly cultivated trees are undoubtedly in their native habitats.

Crataegus Greggiana sp. nov.

C. pubescens Watson, Proc. Am. Acad. 17: 354. 1882. Not *Mespilus pubescens* H.B.K.

Leaves 2–7.5 cm. long, 2–6 cm. wide, broadly ovate to elliptical-ovate, tomentose on both sides, becoming scabrous above, finely and doubly serrate, or lobed towards the apex, with often irregular lobes, acute or obtuse at the apex, broadly cuneate at the base, subcoriaceous, dull; petioles 5 mm. long, tomentose; corymbs 4–8-flowered, corymbs and calyx densely white-tomentose, calyx-lobes lanceolate, acuminate, remotely and irregularly serrate, about 6 mm. long; stamens about 10; styles 3–5; fruit brick-red, about 10–12 mm. thick, globose, tomentose; calyx-lobes appressed, persistent; nutlets usually 4 or 5, grooved on the back, with a conspicuous calyx-scar, 6–7 mm. long, nest of nutlets 7–9 mm. thick. Twigs tomentose, becoming glabrous. Thorns numerous, straight, slender, chestnut-brown, 3–6 cm. long.

Type, *E. Palmer 300*, Saltillo, Coahuila, Mexico, Sept., 1898. (Gray Herb.)

Description of flowers drawn from *E. Palmer 2123*, Mts. 6 miles east of Saltillo, Apr. 15–20, 1880. (Gray Herb.)

"Garden spots, low hills and little hollows between hills, common. No. 300, hawthorn, prolific bearer of brick-red fruit, edible, sold in the market; the pulp has an apple taste; 15–20 feet high, symmetrical top, rough bark, many long thorns, six inches to one foot in diameter, the seeds are taken out of the top of the fruit, which is cooked in sugar and forms a fine preserve."

Specimens examined:

E. Palmer 300. (Gray Herb., herb. N. Y. Bot. Gard., herb. U. S. Nat. Mus., and herb. Arn. Arbor.)

E. Palmer 704, Saltillo, July 28, 1905. (Herb. N. Y. Bot. Gard. and herb. U. S. Nat. Mus.)

E. W. Nelson 6729, General Cépida, Coahuila, Mexico, Apr. 20, 1902. (Herb. U. S. Nat. Mus.)

Crataegus Nelsoni sp. nov.

Leaves 1.5–5 cm. long, 1.5–4 cm. wide, elliptical-ovate to obovate, acute at the apex, cuneate at the base, serrate or doubly serrate, somewhat tomentose below, finely rugose and slightly pubescent above, subcoriaceous; petioles less than 5 mm. long, slightly pubescent; corymbs 3- or 4-fruited, pedicels slightly pubescent; fruit globose, 10–15 mm. thick, slightly pubescent, stamens about 20, calyx-lobes persistent and appressed, entire, slightly pubescent; nutlets 4 or 5, grooved on the back, 7–9 mm. long, nest of nutlets 9–11 mm. thick. Vegetative twigs somewhat pubescent. Thorns very numerous, 3–5 cm. long.

Type, *E. W. Nelson 3217*, near San Cristobal, Chiapas, Mexico, alt. 7000–8800 feet, Sept. 19, 1895. (Herb. U. S. Nat. Mus.)

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North American Plantaginaceae — III *

E. L. Morris

An earlier publication requires the putting on record of

Plantago xerodea nom. nov.

Plantago picta Morris, Bull. Torrey Club **28**: 118. 1901. Not *Plantago picta* Colenso, Trans. New Zeal. Inst. **22**: 481. 1890.

Since the publication of the last paper of this series, the writer has been favored by the opportunity of studying several hundreds of specimens in various herbaria, covering not only the species heretofore treated but others in the different groups under the genus. To this has been added much field work upon some of the species in their natural surroundings.

If we consider Decaisne's treatment of the Plantaginaceae, in DeCandolle's Prodromus, 1852, as the first full and modern treatment, we must consider Asa Gray's treatment of the American species in the Synoptical Flora of North America, 1886, as the first full revision of the group including the then known North American species. Among the perennial plantains there has been little change since 1886 except for the addition of a few new species. Among the annual plantains considerable revision has been made by several authors. So much for the group of species with four stamens, the flowers all perfect and the corolla remaining open and expanded after the stage of anthesis.

For the species with the stamens two or sometimes four, with flowers mainly other than strictly perfect and the corolla mainly, at least in the fertile plants, remaining closed after anthesis, it is necessary that considerable revision be made. The first group of

* [North American Plantaginaceae — I =] "A revision of the species of *Plantago* commonly referred to *Plantago patagonica* Jacquin." Bull. Torrey Club **27**: 105–119. 1900.

North American Plantaginaceae — II. Bull. Torrey Club **28**: 112–122. *pl. 12.* 1901.

species, here considered, are those narrow-leaved annuals whose flowers at the stage of anthesis are *minute* and quite inconspicuous; and whose treatment by American taxonomists has been quite variable.

Plantago elongata Pursh was for many years lost sight of and became almost forgotten. Its nearest relative, *Plantago pusilla* Nuttall, was collected in larger quantities, more often from a wider range, and with such profusion as to swamp the identity of the other species even when recently collected. Pursh described the species as follows:

"*Plantago elongata.* — P. foliis linearibus integerrimis glabris, scapo spicis elongatis subimbricatis foliis longioribus, bracteis ovatis acutis margine membranaceis.
In Upper Louisiana. *Bradbury. v. s. in Herb. Bradbury.* Resembles *P. pauciflora.*"

In 1871, Sereno Watson described a plant which he collected in Salt Lake Valley near the mouth of the Jordan River as *Plantago Bigelovii* A. Gray. He noted it as "resembling *Plantago pusilla*, but with twice larger flowers and fruit, and the capsule (1″ or more in length) more protruded."

In 1883, Engelmann observed a different form from Nuttall's species in plants in his herbarium which had been collected by Geyer on the Nicollet Northwestern Expedition and by Hayden during the survey of Nebraska and the adjacent territories. This form he described under the name *Plantago pusilla*, var. *macrosperma*. His point of emphasis was the measurement of the seeds, and in his herbarium there is extant a sheet containing the following measurement notes:

"1. St. Louis	1.3 mm.
2. Indian Territory broad-leaved form	1.8 "
3. Nicollet, Shienne River	2.4 "
4. Hayden, Yellowstone	2.4 " "

His diagnosis specifies the "larger form, 4 to 7 inches high, with longer much exsert capsules; seeds nearly twice the length of the last, 2.4 mm. or 1.2 lines long. Saline soil of the Western Plains; on the Shienne [etc.]." Engelmann further states "Dr. Gray thinks that he has proofs that this species [*P. pusilla*], or probably the second form of it [*P. pusilla*, var. *macrosperma*], is the lost *P.*

elongata Pursh, * * * but even if so Nuttall's name, now well known since more than 60 years, ought to be retained in place of a doubtful and very inappropriate one."

Asa Gray in the Synoptical Flora gives, in the synonymy of *P. pusilla* Nuttall, "*Plantago elongata* Pursh proves to be this, a bad name." Asa Gray "received Jany. 1, 1883" a specimen from Engelmann with his handwritten label, as follows:

"Plantago pusilla Nutt.
sem. 4. maximis foveolatis
High Prairies. Fort Union
on Yellowstone
F. V. Hayden 1853–4."

— an evident copy of one of Hayden's labels. Of this specimen, Gray annotated in his own hand on the herbarium sheet, below the label, as follows:

"Received Jany. 1, 1883.
This just answers to, and is
from the district of the
Plantago elongata, Pursh
(seen in Hb. Kew.)
But original of Pursh seems to have
several ovules!"

The expression "seen in Hb. Kew.," quoted above, at first suggested that Dr. Gray may have believed the Kew specimen to be Pursh's type of the species, but the following extract from a memorandum by the Director of the Royal Botanic Gardens, Kew, clearly indicates that this is not the type: "The specimen of Plantago elongata, Pursh, in Kew Herbarium seen by Dr. Asa Gray, was collected by Dr. Taylor at Sepulchre Bluffs, Bradbury. There is no specimen at Kew of any Plantago collected by Pursh. . . . The words 'No. 28, Dr. Taylor, Sepulchre Bluffs, Bradbury' and the name 'Plantago elongata Psh.' are in ink, in the handwriting of Sir William Hooker. But the words '= P. pusilla, *Nutt.*' and the mark of '!' . . . are in pencil, in the handwriting of Dr. Asa Gray."

Later than this treatment of the species, the principle of priority as a *rigid* rule of taxonomic work was renewed; and *Plantago elongata* Pursh was given, by many, the benefit of its publication in 1814 as against the date of 1818 for Nuttall's

Plantago pusilla. This action has been followed, more or less consistently, including the writer's work, since that time. It is evident from herbarium annotations, and synonymy wherever it occurs, that the identity of Pursh's species and Nuttall's species has been taken for granted, thus following Asa Gray.

In 1900, P. A. Rydberg, also without reference to *P. elongata* Pursh, segregated from *Plantago pusilla* Nuttall a northern and western form which he called *Plantago myosuroides.* In his description of the species he cites two of the specimens already referred to, namely, Watson's "*Plantago Bigelovii*" from Utah, and Geyer's material from the upper Missouri. The latter is clearly designated by Engelmann. It is quite evident that Rydberg was without knowledge of Engelmann's publication, for his characterization is remarkably like that by Engelmann. He says "nearest related to *P. pusilla* Nutt., differing in the larger size, larger flowers, the longer capsule which is twice as long as the sepals," etc.

From the foregoing it seems evident that Asa Gray had not finished comparing Pursh's type and other material of the species, and that Engelmann and Rydberg were unfortunate in coming no nearer to the identity of Pursh's type. The type specimen, according to present information, is in the Academy of Natural Sciences of Philadelphia; and when placed beside specimens from Geyer, Hayden, Macoun, and Watson, it is hardly distinguishable from some of them, and is readily recognizable as belonging with them and later collections in distinction from the species occurring mainly east and south of the range of *Plantago elongata.* Engelmann and Rydberg each described characters not noted by Pursh; also, in addition to those quoted, characters not noted by the other; and the combination of Pursh's diagnosis with Engelmann's and Rydberg's makes a nearly complete description of the species.

Plantago elongata occurs, so far as ascertained, only in saline and subsaline localities, and only above the 1000 foot contour. The type locality is determinable from the following, kindly sent by Mr. Stewardson Brown of the Philadelphia Academy: "Regarding locality for Pursh's *Plantago:* in Bradbury's Journal page 335 in a 'Catalogue of some of the more rare and valuable plants discovered in the neighborhood of St. Louis and on the Missouri' he says '*Plantago elongata*, near the Maha Village.' According

to the detail part of the Journal this must have been some distance up the Missouri, as the time between March 14 and May 11 was spent in reaching that point; in another place he says, in referring to the distribution of the honey bee, which was not known west of the Mississippi up to 1797, 'They are now found as high up the Missouri as the Maha Nation . . . a distance of 600 miles.'" The name "Maha" in recent bibliographies refers to an Indian tribe now situated in New Mexico. But doubtless Bradbury's use of the name "Maha," among several spellings, was for "Omaha." The location of the Omahas is indicated by the following from Alice C. Fletcher's "Historical sketch of the Omaha tribe of Indians in Nebraska": "The Omaha tribe of Indians live in the State of Nebraska, about 80 miles north of the city of Omaha, on a reservation 12 miles in length north and south, and bound on the east by the Missouri River and on the west by the Sioux City and Omaha Railroad. Of the various tribes living in Nebraska when the white settlers first entered the Territory the Omahas are the only Indians remaining upon their ancient home lands. In the absence of any written records it is almost impossible to fix dates, but it seems probable that the Omahas have dwelt near their present location for the past two centuries or more. Their traditions point to an earlier home in the Ohio valley, whence they were driven by wars; slowly migrating across the Mississippi River, up the Des Moines and its tributaries to their headwaters, thence westward until the Missouri was reached. Crossing this river, the people gradually made their way south to their present place of residence." Edwin James, in the narrative of the Long Expedition, also refers to the location of the "Omawhaws," as follows: "What length of time the Omawhaws have resided on the Missouri is unknown; but it seems highly probable that they were not there when Mr. Bourgmont performed his journey to the Padoucas, in the year 1724, as he makes no mention whatever of them. It would seem, indeed, that they had separated from the great migrating nation . . . on or near the Mississippi, and that they had since passed slowly across the country, or perhaps up the St. Peter's, until they finally struck the Missouri at the mouth of the Sioux River. This is rendered highly probable by the circumstance of Carter having met with them on the St. Peter's in the year 1766, associated with

the Shienne and others, all of whom he represents as bands of the Naudowessie nation." C. A. Geyer collected his specimens (*no. 279*) in "arid saline plains valley of Shian River near its mouth (upper Missouri)," now the Cheyenne River, which empties into the Missouri about 35 miles, air line, northwest of Pierre, South Dakota. One of Hayden's specimens of *Plantago elongata* bears the following label:

"FLORA NEBRASKANA
Plantago pusilla Nuttall
Semminibus 4 maximis
High Prairies, Ft. Union.
DR. F. V. HAYDEN, Leg. 1853–4."

A map of Nebraska and Dakota, etc., by Maj. John Warren, Mch. '67, accompanying Final (4th) Report of U. S. Geological Survey of Nebraska, etc. by F. V. Hayden, Washington, 1872, contains location of Ft. Union, Long. 104° west, Lat. 48° north, on the north bank of the Missouri River, about five miles above the mouth of the Yellowstone River. This location is given on the map of 1870. There is no modern use of this name for this location within the information of present day atlases. Pound & Clements, in their "Phytogeography of Nebraska," indicate the limited habitat of the species, when they say of ". . . Xerophytes of high prairies and sand hills. . . . P. elongata, which is confined almost wholly to alkaline situations, seems to exhibit a tendency to become a halophyte."

The limiting of this species accomplishes two fortunate things: It recognizes the applicability of Pursh's name, because of the elongated (more or less interrupted) spikes, and long carinate bracts; second, the retention of the well-known and long-used name published by Nuttall for the species common in the lower Mississippi Valley and its tributaries, and eastward along the Ohio, the Tennessee, the Gulf Coast, and up the Atlantic seaboard to Massachusetts.

Plantago pusilla Nuttall has been well known to all collectors east of the Mississippi and south of the Great Lakes. The name had become almost a "household word" among botanists. This name was retired because of the priority of Pursh's name, during the latter part of the now long period in which the species were

constantly confused. The name *pusilla* is applicable in every sense of the word to practically every condition of the species, as commonly found in its sandy or otherwise characteristic habitat. In distinction from it, *Plantago elongata* Pursh is noticeably lank and lean and its strength is most emphasized in the woody character of its tissues, especially the tap root, which is heavy in proportion to the rest of the plant, as is typical for plants in saline localities.

Plantago pusilla Nuttall, 1818, and the less used and often forgotten *Plantago hybrida* Barton, 1818, applied to the same species, may yet be the cause of some nomenclatorial controversy. The writer has tried by every known method to determine the priority of one of these names. Dr. Barnhart * has discussed the question quite fully. And Nuttall's name is here retained as prior on the following "internal evidence":

Philadelphia, 1818	Nuttall, Gen.	Barton, Comp. Fl. Phila.
Title deposited to secure copyright	April 3, 1818.	July 9, 1818.
Preface dated	May 27, 1818.	July 11, 1818.
Cross references		Preface acknowledgment of Nuttall's kindness in permitting use of Nuttall's work.
		Text citations to Nuttall's work.
Certified by	D. Caldwell, *Clerk of the District of Pennsylvania.*	D. Caldwell, *Clerk of the District of Pennsylvania.*

Against this, however, is the argument (?) of Otto Kuntze,† for Barton, January 1818. For this, Kuntze gives no basis or reference.

Barton goes to some length to explain his separation of *P. hybrida* from *P. maritima*, by which name he had called it in his Prodromus Florae Philadelphicae, 1815, but *P. hybrida* he now (1818) emphasizes by being "destitute of everything like woolliness at the base," and other distinctive characters.

Plantago pusilla and *P. heterophylla* have been confused by many collectors who failed to consider the seeds, in the forms of the first with slight toothing of the leaves, and in the forms of the latter without such toothing. It is interesting to note that Nuttall so confused them in a collection of his own from Arkansas (not his type), one plant of *P. heterophylla* with entire leaves and 10

* See his Nomenclatural notes, Bull. Torrey Club **24**: 409. 1897; **26**: 379. 1899.

† Rev. Gen. Pl. 3^2: 160. 1898.

seeds being placed with typical *P. pusilla* with entire leaves and 4 seeds, these being now in the Academy of Natural Sciences of Philadelphia.

Plantago pusilla from the Columbia River and neighboring parts of Washington and Oregon varies somewhat from the eastern forms. It is noteworthy that the earliest record, available at this time, of the species from the Columbia drainage is May, 1887. It seems probable that the plant is here introduced and naturalized. But present data afford no explanation of the method of introduction. Few specimens attain normal dimensions, and the spikes often are but few-flowered.

The species has long been known as far east as Long Island and Connecticut, more recently from Rhode Island, and now, by the careful search of Mr. E. B. Chamberlain, from Massachusetts, at Seekonk, June 13, 1901.

Plantago pusilla Engelmanni (see below, p. 528) was described by Engelmann, in 1883, as a variety *major* of *P. pusilla*, characterized as: "much larger and stouter, leaves lanceolate-linear, often 1½ to 2 lines wide, the larger ones laciniate with few long teeth or lobes; scapes densely woolly at base, with the elongated spike often 9 inches high; bracts acute, longer than the sepals; seeds intermediate in size between the two other forms — Near Atoka, north of Red River in the Indian Territory." The size of these seeds is given in the note quoted above (under *P. elongata*) as 1.8 mm. for the "Indian Territory broad-leaved form." Several specimens belonging here are intermediate with *P. pusilla* in the woolliness at the base. The extreme form in this respect is Engelmann's own type. So, this character must be considered as relatively unimportant. This woolliness at the base, together with the laciniate toothing of many of the leaves and the extension of the bracts beyond the calyx, superficially confuse this subspecies with some plants of *P. heterophylla*, but the difference may be at once recognized by the number of seeds and their size and shape, as well as the more rigid habit. This subspecies seems to be limited to Missouri, Arkansas, Indian Territory, and Oklahoma. There is no apparent intergradation with *P. elongata* Pursh, but there is regular intergradation with *P. pusilla* in Missouri and Arkansas, and questionably in Kansas.

Plantago Bigelovii A. Gray requires little discussion. With a range from south central California northward into British Columbia, and only in low valleys and along the seacoast, it is readily distinguished from the other annuals of the genus. In the low valley forms, the habit tends to be slender, with a somewhat tardy maturing of the seeds. In the coastal forms, the habit is pronouncedly stockier, with an early maturity. About the region of San Francisco Bay the two forms strongly intergrade. The type, from Benicia, in the Gray Herbarium, is a depauperate plant. Evidently the remaining Bigelow specimens, if any, were destroyed in drawing the diagnosis in 1857. Additional plants, collected by Dr. E. L. Greene in 1874, were used in the emended description in the "Botany of California" as there cited, and as labeled "Syn. Fl. N. Amer." in the Gray Herbarium.

Plantago heterophylla Nuttall was described from Arkansas material which was without flowers or fruit. The plants were in a fine vegetative condition, showing well the fibrous roots, the mass of woolly hairs at the crown of the short caudex, long narrow herbaceous somewhat fleshy leaves with prominent scattered teeth. The spikes, flowers, and fruit were early described by Asa Gray in 1856 in his Manual, second edition. The extremes of the species are very unlike but they are connected by an innumerable number of intermediate forms. There are those so similar to depauperate forms of *P. pusilla* that they may be recognized only by the number and form and surface of the seeds. Others are so tall and erect and slight that they simulate *P. pusilla Engelmanni;* others so depressed-spreading and laciniate-toothed that they scarcely seem to be the same species. But the fruits and seeds run true.

Between 1880 and 1890, there was collected a series of plants of this species which were apparently new to the known California flora. They were from the environs of San Francisco Bay southward, here and there, to Tia Juana, Lower California, just over the international boundary. E. L. Greene described these as *P. californica*, in 1885. The vegetative characters of the Californian specimens vary as do (and parallel to) the southern and eastern forms. There is one difference in the fruiting stage, namely, the smaller number of seeds, often only five to eight, due

very probably to incomplete fecundation of the ovules. It is highly significant, too, that the collections of this species in California seem to have ceased with the 1890's; especially significant, with such men as Heller, Abrams, Orcutt, Parish, and others in the field since that time. Under the data available, the present conclusion is that *P. heterophylla* Nuttall, 1837 (*P. californica* Greene, 1885), was for a few years adventive in California.

It is a pleasure gratefully to acknowledge the kindness and interest of officers of institutions, and others, who have offered or sent material for study; and duly to credit them under each species.

Key to species treated in this paper

[Biennials (normally). *P. virginica* group.]
Annuals, seeds pitted.
- Seeds 4, small, symmetrical.
  - Pacific Slope native species. Bracts carnulose-keeled, pitted when dry..... *P. Bigelovii.*
  - Central and Eastern native species. Bracts not pitted when dry.
    - Campestrian, above 305 meters elevation (= ± 1000 ft.). Bracts saccate-keeled; seeds four times as long (2 mm.) as broad..... *P. elongata.*
    - Mississippi drainage, Gulf region, Atlantic Slope and Coast, low elevations. Bracts not keeled, though somewhat swollen; seeds not more than three times as long as broad.
      - Leaves usually entire; seeds about two and a half times as long (1 mm.) as broad. (Introduced and naturalized in Puget Sound region and tributaries.)..... *P. pusilla.*
      - Leaves usually distantly laciniate-toothed; seeds about three times as long (1.8 mm.) as broad. (Known only from Indian Territory east to Missouri River.) *P. pusilla Engelmanni.*
- Seeds 10–30 (or fewer by abortion), minute, unsymmetrical..... *P. heterophylla.*

PLANTAGO BIGELOVII A. Gray, in Whipple, Pacif. R. R. Rep. **4**: 117. 1857; *descript. emend.* Bot. Calif. **1**: 612. 1876. Not *P. Bigelovii* S. Watson, Bot. King Exped. **5**: 212. 1871.

A low, erect, subcarneous, acaulescent annual. Roots one or two, with the secondaries fibrous, slender, numerous. Leaves basal, erect to ascending, more or less carnulose, glabrous to spar-

ingly pubescent, several to many, sessile, linear to linear-filiform, scarious-expanded at the base, entire, obtusely (callous-) tipped, obscurely 1–3-nerved, 3–10 cm. × 1–4 mm. Scapes basal and axillary, erect, slightly to twice surpassing the leaves, terete, a little thickened at the summit, appressed-pubescent, one to ten (even fifteen?), 5–15 cm. tall. Spikes cylindrical, with the flowers more or less imbricate, few- to thirty-flowered. Bracts closely subtending the flowers, about equaling the calyx, carnulose-keeled and saccate, broadly ovate, margins scarious and as wide as the herbaceous center, obtuse, 2.5 mm. × 3 mm. The flowers inconstantly dimorpho-subdioecious. Calyx glabrous, its divisions scarious, with slightly herbaceous midribs, obovate, rounded, 2 mm. × 1.5 mm. Corolla minute, just exceeding the capsule, its lobes spreading, often not closing in fruit, scarious, with darker midrib, lanceolate-triangular, acute. Stamens two, little if at all exserted. Pyxis one third longer than the calyx, oblong-ovoid, abruptly rounded, circumscissile just below the middle. Seeds four to six, black, rough, oblong, 1.5 mm. × 0.5 mm.

Type specimen is Bigelow's collection, April 23, 1854, from Benicia, California, in the Gray Herbarium.

Sixty-one sheets or specimens from British Columbia, Washington, and California have been examined, in herbaria as follows: 6, Geological and Natural History Survey of Canada; 9, Columbia University and New York Botanical Garden; 4, Field Museum of Natural History; 12, Gray Herbarium; 6, Doctor Edward Lee Greene; 7, Missouri Botanical Garden; 3, Academy of Natural Sciences of Philadelphia; 10, United States National Herbarium; 1, University of Pennsylvania; and 3, my own herbarium.

PLANTAGO ELONGATA Pursh, Fl. Am. Sept. **2**: 729. 1814

P. pusilla Decaisne, *pro parte*, in DC. Prod. **13'**: 696. 1852.

P. Bigelovii S. Watson, Bot. King Exped. **5**: 212. 1871. Not A. Gray, in Whipple, Pacif. R. R. Rep. **4**: 117. 1857.

P. pusilla var. *macrosperma* Engelmann, Bot. Gaz. **8**: 175. 1883. Not *P. macrosperma* Steudel, Flora **32**: 405. 1849.

P. pusilla A. Gray, *pro parte*, Syn. Fl. **2**[1]: 392. 1886. Not Nuttall, Gen. N. Am. Pl. **1**: 100. 1818.

P. elongata Auct. Am. plur., *pro parte*.

P. myosuroides Rydberg, Mem. N. Y. Bot. Gard. **1**: 369. 1900.

A relatively low, erect, rather coarse, acaulescent annual, of subsaline and saline situations, noticeably cinereous-pubescent in

its lower half, with the general habit of being erect, usually higher than wide, and with the oldest scapes becoming decumbent with age. Root normally one, long, stout, woody, and large in proportion to the plant; secondaries few, filiform, and shorter than the primary. Leaves basal, erect or slightly spreading, sometimes with tips recurved, one half to three fourths as high as the plant, herbaceous or slightly fleshy in larger forms, strongly cinereous-pubescent for the lower half, few to numerous, gradually expanded into the semi-clasping base (two to four times as long as wide), linear, entire or remotely callous-denticulate, callous-tipped even when long-acuminate, 1-nerved, 3–10 cm. × 0.5–2 mm. Peduncles axillary, erect, or the oldest bowed outward from the crown, equaling or shorter than the leaves, rarely longer, terete, not striated, or but slightly so below the spike, one to many, 3–8 cm. high. Spike erect, cylindrical, slender, with the flowers often distant, 1–10 cm. long. Bracts closely subtending the flowers, rather uniformly ascending, about equaling the calyx, herbaceous-carnose, distantly spur-keeled to 0.5 mm. below basal attachment and 0.5 mm. divergent from peduncle, triangular-ovate, scarious, with margins one third as wide as the herbaceous center, entire, acute or acutish, 2 mm. (from spur to apex) × 1.5 mm. Flowers subperfect. Calyx glabrous, inequilateral, its divisions obovate, scarious margins wider than the distinctly herbaceous midrib, apex truncate-rounded, about the width of the bract, 1.75 mm. long. Corolla very minute, rarely closing to form a beak, throat as long as the lobes, the lobes triangular, entire, acute, 0.5 mm. × 0.25 mm. Stamens two, included. Pyxis glabrous, twice surpassing the calyx, oblong-ovate, truncate-rounded, with the base of style persistent as a distinct tubercle, circumscissile just below the middle, 2.5–3 mm. × 1.5 mm. Seeds four, finely rugose-pitted, dark seal-brown, elliptical, 2 mm. × 0.5 mm.

Type specimen is Bradbury's collection from "Upper Louisiana," in the herbarium of the Academy of Natural Sciences of Philadelphia.

Thirty-seven sheets or specimens from Assiniboia, North Dakota, South Dakota, Nebraska, Oklahoma, Montana, Colorado, and Utah, have been examined, in herbaria as follows: 5, Geological and Natural History Survey of Canada; 6, Columbia University and New York Botanical Garden; 5, Gray Herbarium; 1, Doctor Edward Lee Greene; 8, Missouri Botanical Garden; 2, Academy of Natural Sciences of Philadelphia; 5, United States National Herbarium; 5, University of Nebraska.

PLANTAGO PUSILLA Nuttall, Gen. N. Am. Pl. **1**: 100. 1818

P. maritima Barton, Prod. Fl. Phila. 26. 1815. Not Linnaeus, Sp. Pl. 114. 1753.

P. hybrida Barton, Comp. Fl. Phila. **2**: 214. 1818; Fl. N. Am. **3**: 77. *pl. 98. f. 1.* 1823.

P. linearifolia Muhlenberg (?), Cat. ed. 2, 15. 1818, *nomen nudum.* — Torrey, Fl. U. S. 185. 1824, *cit. excl.**

P. pusilla Decaisne, *pro parte*, in DC. Prod. **13**[1]: 696. 1852.

P. elongata Auct. Am. plur. Not Pursh, Fl. Am. Sept. **2**: 729. 1814.

An inconspicuous, very low acaulescent annual, of sandy or dry situations, occasionally intruding upon woodlands, mostly glabrous or with slight pubescence about the crown. Roots one or two, normally short, small in proportion to the plant, weak, the secondaries numerous, filiform-fibrous, and usually longer than the primaries. Leaves basal, erect or somewhat spreading, one fourth to one half as high as the plant or even shorter in depauperate individuals, herbaceous or slightly fleshy, 4 or 5 to numerous, abruptly expanded into the semi-clasping base (a little longer than broad), filiform to linear, sometimes narrowed below, entire or rarely remotely callous-denticulate, apex callous, blunted or sometimes acutish, 1-nerved or in wider forms obscurely 3-nerved, the outer nerves being about equidistant from midrib and margin, 1–5 cm. × 0.5–2 mm. Peduncles axillary, erect to spreading-ascending, four times as long as, to a little shorter than, the leaves, terete, becoming striate when dry especially near the base of the spike, 1 to many (160 counted on one individual from Long Island), 3–10 cm. high. Spikes erect, cylindrical, slender, with flowers at first imbricate, at length even much scattered. Bracts closely subtending the flowers, at first erect, later spreading by the expanding fruit, equaling the calyx, surpassing it in etiolated forms, herbaceous, carnulose, tending to subsaccate dorsally, triangular-ovate, scarious, with margins one half as wide as the herbaceous center, entire, rounded-obtuse or blunt, 1.5–2 mm. × 1.25–1.5 mm. Flowers subperfect. Calyx glabrous, inequilateral, its divisions obovate, with scarious margins wider than the

* Torrey, *loc. cit.*, gives "Muhl. Cat. p. 15?." Torrey later, and many others, give "Muhl. Cat. p. 15? ex Torr. Fl. U. St. 185." This citation, by its form, naturally refers to Muhl. Cat. ed. 1, Lancaster, 1813. The Plantaginaceae are listed on page 16; and *P. linearifolia* is not included in the list. Torrey did specify the second edition of Muhlenberg's Catalogue in his bibliography at the beginning of his Flora, but it must have been constantly overlooked. Accordingly, Torrey's citation, and those following it, must be considered incomplete and misleading.

distinctly herbaceous midrib, apex rounded or bluntly apiculate by the excurrent midrib, less than the width of the bract. Corolla very minute, forming an incompletely closed beak above a hardly discernible throat; its lobes triangular, entire, acute, 0.5 mm. × 0.25 mm. Stamens two, included. Pyxis one third surpassing the calyx or little more, glabrous, ovate--ovoid, truncate-rounded or with the base of the style persistent in the slightly depressed apex, circumscissile just above the lower third, 1.75 mm. × 1 mm. Seeds 4, coarsely rugose-pitted, dark olive-brown, elliptical-oblong, 1.25 mm. × 0.5 mm.

Woodland forms intergrade with the following subspecies.

Type specimen is Nuttall's collection, from "Arkansas," in the herbarium of the Academy of Natural Sciences of Philadelphia.

One hundred and seventy-four sheets or specimens from Massachusetts, Rhode Island, Connecticut, New York (Long Island), New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, Virginia, South Carolina, Georgia, Florida (?), Illinois, Kentucky, Tennessee, Alabama, Missouri, Arkansas, Kansas, Indian Territory, and Texas; and (introduced) in Washington, Oregon, and California, have been examined, in herbaria as follows: 2, Brooklyn Institute Museum; 28, Columbia University and New York Botanical Garden; 14, Field Museum of Natural History; 16, Gray Herbarium; 6, Doctor Edward Lee Greene; 47, Missouri Botanical Garden; 22, Academy of Natural Sciences of Philadelphia; 7, Mr. Wilhelm N. Suksdorf; 21, United States National Herbarium; 1, University of Nebraska; 6, University of Pennsylvania; and 4, my own herbarium.

Plantago pusilla Engelmanni nom. nov.

P. pusilla var. *major* Engelmann, Bot. Gaz. **8**: 175. 1883. Not *P. major* Linnaeus, Sp. Pl. 112. 1753.

A rather large annual, varying in height to 25 cm., about twice the dimensions of *P. pusilla* when at the same stage of development, noticeably herbaceous, densely woolly at the base. Root usually one, secondaries about the length of the primary, numerous, filiform, fibrous, the crown densely pubescent or even woolly among the leaf-bases. Leaves basal, erect or strict-ascending, glabrous to cinereous-pubescent, numerous, with petiole distinguishable from the lanceolate-linear blade, attenuate at both ends, in maturity with few prominent scattered callous teeth which are either straight or falciform, acute except for the callous tip, 1–3-nerved,

4–12 cm. × 1–4 mm. Peduncles axillary, erect to strict-ascending, much surpassing the leaves, terete below, channeled above, cinereous above, densely woolly below, numerous, 5–25 cm. high. Spikes erect, thin, with the flowers scattered or in false pairs and clusters. Bracts closely subtending the flowers, erect or nearly so, typically one half surpassing the calyx, herbaceous, saccate, triangular-lanceolate, margins narrowly scarious, apex strictly acute, about 2.5 mm. long. Flowers apparently perfect. Calyx glabrous, its divisions inequilateral, with the scarious margins distinctly wider than the herbaceous midrib, apex obtuse, equaling the width of the bract. Corolla very minute, forming incompletely closed beak, with throat short, its lobes triangular, entire, acute, about 0.5 mm. long. Stamens 2, included. Pyxis more than one third surpassing calyx, ovoid-oblong, obtusish, circumscissile at about the lower third. Seeds four, obscurely pitted, very dark brown, oblong, 1.8 mm. (or a little less) × 0.33 mm.

This subspecies intergrades strongly with woodland or otherwise sheltered individuals of the typical form.

Type specimen is G. D. Butler's collection from near Atoka, Indian Territory, in the Missouri Botanical Garden, Engelmann Herbarium.

Ten sheets or specimens from Indian Territory and Missouri have been examined, in herbaria as follows: 4, Gray Herbarium; 4, Missouri Botanical Garden; 2, New York Botanical Garden.

PLANTAGO HETEROPHYLLA Nuttall, Trans. Am. Phil. Soc. II. **5**: 177. 1837

P. caroliniana Pursh (?), Fl. Am. Sept. **1**: 98. 1814. Not Walter, Fl. Carol. 85. 1788.

P. pusilla Decaisne, *pro parte*, DC. Prod. **13**[1]: 696. 1852. Not Nuttall, Gen. **1**: 100. 1818.

P. perpusilla Decaisne, in DC. Prod. **13**[1]: 697. 1852.

P. californica Greene, Bull. Calif. Acad. I. **3**: 123. 1885. Not *P. Durvillei* var. *californica* Fischer & Meyer, Ind. Sem. Petrop. 1839–40.

A very variable, low, erect or spreading, herbaceous, glabrous, or partly woolly-pubescent annual. Roots one or two, often very short; secondaries fibrous, slender, usually very numerous. Leaves basal, erect or spreading, herbaceous, usually very thin, few to many, blade and petiole indistinguishable or very gradually expanded below, linear, narrow, acute or rarely blunt, 1–3-nerved,

3–12 cm. × 0.75–2.5 mm., entire to toothed, the straight or curved teeth sometimes 1 cm. long. Peduncles axillary, erect to spreading, terete, slender, glabrous, or often woolly at the base, few to many, 4–15 cm. high. Spikes racemiform, often much and irregularly interrupted, 10–30- or more-flowered. Bracts usually conspicuous, twice surpassing to equaling the calyx in fruit, closely involving the calyx, herbaceous, with scarious margins at the lower half (half as wide as the herbaceous center), triangular, ovate, entire, blunt or obtusish at the apex, 2 mm. × 1.5 mm. when mature. Flowers normally perfect. Calyx glabrous, equilateral or slightly inequilateral, its divisions ovate, with wide scarious margins and narrow prominent green midrib, ovate, blunt, about the width of the bract. Corolla minute, with hardly distinguishable throat, its lobes erect over the fruit, triangular, entire, acute, 0.25 mm. × 0.10–0.15 mm. Stamens two, included. Style slender, exserted, about 1 mm. long, at length its base persistent as a distinct tubercle. Pyxis fusiform-ovoid, circumscissile just below the middle, 2.5–3 mm. × 2 mm. Seeds 10–25 or more, or by abortion fewer, irregular by mutual pressure, blackish brown, oblong, 0.75 mm. × 0.35–0.40 mm.

Type specimen is Nuttall's collection, from Arkansas, in the herbarium of the Academy of Natural Sciences of Philadelphia.

One hundred and ninety-five sheets or specimens from New Jersey, Pennsylvania, Delaware (?), Maryland, North Carolina, South Carolina, Georgia, Florida, Illinois, Kentucky, Tennessee, Alabama, Mississippi, Missouri, Arkansas, Louisiana, Texas, and (introduced) in California and Lower California, have been examined, in herbaria as follows: 3, President Ezra Brainerd; 2, Brooklyn Institute Museum; 38, Columbia University and New York Botanical Garden; 15, Field Museum of Natural History; 32, Gray Herbarium; 7, Doctor Edward Lee Greene; 45, Missouri Botanical Garden; 22, Academy of Natural Sciences of Philadelphia; 1, Mr. Wilhelm N. Suksdorf; 20, United States National Herbarium; 7, University of Pennsylvania; and 3, my own herbarium.

MUSEUM OF THE BROOKLYN INSTITUTE
OF ARTS AND SCIENCES.

Studies on the Rocky Mountain flora — XIX

PER AXEL RYDBERG

Muhlenbergia squarrosa (Trin.) comb. nov.

Vilfa squarrosa Trin. Mém. Acad. Pétersb. VI. Sci. Nat. **5**[2]: 100. 1840.

Vilfa depauperata Torr. in Hook. Fl. Bor.-Am. **2**: 257. 1840. Not *Muhlenbergia depauperata* Scribn. 1884.

Sporobolus depauperatus Scribn. Bull. Torrey Club **10**: 63. 1883.

The group of grasses which Torrey, Trinius, and Thurber included under the generic name *Vilfa* has been transferred from *Sporobolus* to *Muhlenbergia*. See Bull. Torrey Club **32**: 599, 600. As this species is a member of that group, it also should be transferred. It is doubtful which of the two specific names, *squarrosa* or *depauperata* is the older, but the latter is not available, as there is already a *Muhlenbergia depauperata* Scribn.

Agrostis atrata sp. nov.

A somewhat tufted perennial; stems 1.5–3 dm. high, few-leaved, more or less bulbous at the base; sheaths glabrous, shorter than the internodes; ligules ovate, 1.5–2.5 mm. long; leaf-blades 5–10 cm. long, about 2 mm. wide, flat, smooth; panicle 5–8 cm. long, rather open; branches ascending, the lower ones 2–3 cm. long; spikelets dark purple, about 2 mm. long; empty glumes nearly equal, abruptly acute or acuminate; flowering glume nearly as long, obtusish; palet slightly shorter and more than half as broad.

The type number of this species was determined by Professor A. S. Hitchcock as *A. Thurberiana*, but it differs from that species in the following respects: The empty glumes are dark purple as in *A. aequivalvis*, abruptly acute or acuminate; the inflorescence is short and open and the stem is few-leaved. In *A. Thurberiana* the empty glumes are green, only tinged with purple at the apex, narrowly lanceolate and gradually acute; the inflorescence is long and narrow, and the stem is very leafy. It differs from *A. aequivalvis* in the smaller spikelets, only 2 mm. long, instead of 3 mm.,

and the shorter rachilla, which is barely one third as long as the flower.

BRITISH COLUMBIA: Yoho Valley, Sept. 6, 1904, *John Macoun 64787* (type, in herb. N. Y. Bot. Gard.); also *64788;* Selkirk Mountains, 1904, *C. H. Shaw 424;* Roger's Pass, July 31, 1890, *John Macoun.*

Agrostis Bakeri sp. nov.

A cespitose perennial; stem about 3 dm. high, erect, slightly geniculate below, glabrous; basal leaves numerous; sheaths close, slightly scabrous, those of the stem-leaves often shorter than the internodes, ligules ovate, 2 mm. long, dentate; leaf-blades flat, 1–2 mm. wide, 5–10 cm. long; panicle ovoid, 8–10 cm. long, open; branches ascending, branched above the middle, the lower 3–5 cm. long; pedicels somewhat scabrous, thickened below the spikelets; empty glumes nearly equal, purple, 2–2.5 mm. long, acuminate; flowering glume three fourths as long, obtuse, bearing above the middle a dorsal straight awn a little exceeding the glume; palet none or minute.

The type specimen of this species was determined as *A. tenuis erecta* by Professor Scribner and included by Professor Hitchcock in *A. idahoensis* (the latter united *A. idahoensis* Nash and *A. tenuis* Vasey). Professor Hitchcock remarked that Baker's *no. 150* "is yet more robust and there is a short straight awn on the flowering glume." These are the essential characters by which it is to be separated from *A. idahoensis.* The empty glumes are also larger and more acuminate. One of the other specimens referred to *Agrostis Bakeri*, viz. *no. 37*, was included in *A. hiemalis geminata* by Hitchcock. Of this he remarked that it has "the awn but a more diffuse panicle." It is evident that Baker's *no. 37* and *no. 150* belong to the same species, the former being younger and less well developed. *Agrostis Bakeri* is most closely related to *A. geminata* Trin., differing in the broader leaves, ascending instead of divaricate branches of the panicle, smaller spikelets, and shorter awns. In *A. geminata* the basal leaves are filiform and involute, the spikelets about 3 mm. long and the awn equaling the empty glumes. *A. Bakeri* grows in the mountains at an altitude of 3000–3200 m.

COLORADO: Near Pagosa Peak, August, 1899, *C. F. Baker 150* (type, in herb. N. Y. Bot. Gard.); *no. 37* and *no. 148.*

Deschampsia confinis (Vasey) sp. nov.

Deschampsia caespitosa confinis Vasey; Beal, Grasses N. Am. **2**: 369. 1896.

The only character given by Professor Beal is the unusual length of the ligules. To this should be added a narrow inflorescence with strongly ascending branches and a long awn inserted near the base of the floral glume. I think that these characters make the plant specifically distinct from *D. caespitosa*. *D. confinis* ranges from southern Utah and Arizona to southern California.

Sphenopholis intermedia (Rydb.) comb. nov.

Koeleria truncata major Torr. Fl. U. S. **1**: 117. 1824.
Eatonia intermedia Rydb. Bull. Torrey Club **32**: 602. 1905.
Sphenopholis pallens major Scribn. Rhodora **8**: 145. 1906.

Poa callida sp. nov.

Perennial, with a creeping rootstock; stem 3–5 dm. high, somewhat flexuose, striate and glabrous; ligules lanceolate, long-attenuate, 5–6 mm. long; leaf-blades flat, flaccid, 5–12 cm. long, about 3 mm. wide, smooth; sheaths exceeding the internodes; panicle open, 1–1.5 dm. long; branches spreading or reflexed, scabrous; the lower ones in 4's to 6's, 5–7 cm. long, spikelet-bearing above the middle; spikelets about 3 mm. long, 2- or 3-flowered, light green, strongly compressed; first empty glume subulate, 1-nerved, 2 mm. long; the second slightly broader, 3-nerved, 2.5 mm. long, glabrous; floral glumes 3 mm. long, strongly 5-nerved, acuminate, glabrous except the keel, which is slightly silky below; cobweb scant but long.

This species is related to *Poa occidentalis* Vasey, but is a weaker and more flaccid plant, has very long and conspicuous ligules, narrow flowering glumes, which are still more strongly nerved. The spikelets resemble those of *P. nervosa*, but are smaller; the floral glumes are smooth and with a distinct cobweb. The type was named *P. serotina*, which also it resembles, but in that species the floral glumes are less compressed, with obsolete intermediate nerves.

MONTANA: Warm Springs, Helena, July 13, 1895, *Rydberg 2145* (type, in herb. Columbia Univ.).

Poa scaberrima sp. nov.

A tufted perennial, with numerous intravaginal innovations; stem 3–5 dm. high, 2- or 3-leaved, glabrous; ligules lanceolate, acuminate; leaf-blades filiform, involute, very scabrous, pale green; blades of the basal leaves 8–15 cm. long, less than 1 mm. wide; those of the stem-leaves 1–5 cm. long, erect; panicle elliptic, dense, 4–7 cm. long; branches short, strongly ascending; spikelets about 1 cm. long; empty glumes ovate, nearly equal, 4–5 mm. long, glabrous; floral glumes ovate, acuminate, pale, slightly tinged with purple, 5–6 mm. long, strongly 5-nerved, and conspicuously scabrous.

The type was named by Professor Scribner *Poa Cusickii*, from which it differs, however, in the larger, paler, very scabrous, acuminate floral glumes and the pale scabrous filiform leaves. In habit it more resembles *P. idahoensis* and *P. subaristata*. From the former it differs in the dense inflorescence and broader glumes; from the latter in the broader glumes and the lanceolate ligules.

IDAHO: Beaver Cañon, June 27, 1895, *Rydberg 2055* (type, in herb. N. Y. Bot. Gard.).

Poa Helleri sp. nov.

A tufted perennial; stem slender, 4–6 dm. high, often purple-tinged below; ligules lanceolate, acuminate; leaf-blades very slender, flaccid, 5–15 cm. long, 1 mm. wide, more or less involute, scabrous; panicle rather loose, 8–10 cm. long; branches ascending; spikelets about 1 cm. long, 4- or 5-flowered; empty glumes linear-lanceolate, 3-nerved, glabrous, unequal, 4–5 mm. long; floral glumes linear-lanceolate, about 5 mm. long, strigulose below, scabrous on the upper part.

The type was named *Poa Sandbergii*, but it can scarcely be referred to that species. It differs in the pale inflorescence, larger and much narrower, conspicuously strigose floral glumes. In habit it resembles *P. idahoensis*, but evidently belongs to the same group as *P. nevadensis*, from which it differs in the slender habit and the narrower glumes with a different pubescence.

IDAHO: Lake Waha, *A. A. & E. Gertrude Heller 3274* (type, in herb. Columbia Univ.).

Poa curta sp. nov.

Perennial, with a horizontal rootstock; stem glabrous, 4–5 dm. high; sheaths short, glabrous; ligules about 1 mm. long, truncate;

leaf-blades 2–5 cm. long, 3–5 mm. wide, abruptly acute, spreading, dark green; inflorescence short, open, 4–5 cm. long; branches in 2's to 4's, spreading, 1–2 cm. long, spikelet-bearing above the middle; spikelets light green, strongly compressed, about 6 mm. long, 2–4-flowered; empty glumes glabrous, but scabrous on the veins, lanceolate, the first 3 mm. long, 1-nerved, the second 4 mm. long, 3-nerved; floral glumes lanceolate, scabrous-strigulose, strongly 5-nerved, 5 mm. long.

This species is related to *P. occidentalis* (Vasey) Rydb. (*P. flexuosa occidentalis* Vasey), but differs in the short ligules and the short broad leaves.

WYOMING: Spread Creek, at an altitude of 2900 m., July, 1897, *F. Tweedy 13* (type, in herb. N. Y. Bot. Gard.).

Poa subreflexa sp. nov.

Perennial, with a horizontal rootstock; stem ascending, 5–6 dm. tall; lower sheath finely and retrorsely strigulose; ligules very short and truncate; leaf-blades flat, flaccid, 7–10 cm. long, 3–4 mm. wide, spreading; panicle open, about 1 dm. long; branches reflexed, the lower in 3's or 4's, 1–3 cm. long; spikelets pale green, 6–7 mm. long, 3- or 4-flowered; empty glumes glabrous, with broad scarious margins, lanceolate, the first 1-nerved, about 3 mm. long, the second 3-nerved and about 4 mm. long; flowering glumes lanceolate, 5 mm. long, scabrous-strigulose, strongly 5-nerved.

This species is related to *P. Wheeleri* and *P. Olneyae*, but differs from both in the reflexed branches of the panicle and the broad flaccid leaves.

COLORADO: In shade of spruces on the bank of a creek, mountains north of Steamboat Springs, July 26, 1891, State Agricultural College distribution *no. 3731* (type, in herb. N. Y. Bot. Gard.).

Poa subtrivialis sp. nov.

Perennial, with a rootstock; stem slender, 4–6 dm. high, smooth; ligules very short and truncate; sheaths narrow, striate, exceeding the nodes; leaf-blades erect, flaccid, 8–15 cm. long, about 2 mm. wide, flat, dark green; panicle narrow, 1–2 dm. long; branches erect, scabrous, spikelet-bearing above the middle; spikelets light green, 3–4 mm. long, 2–3-flowered; first empty glume very narrow, 2 mm. long, smooth; the second lanceolate, 2.5 mm. long, prominently 3-nerved; floral glumes 2.5 mm. long, glabrous, obscurely nerved; cobweb very scant.

This is closely related to the European *P. nemoralis*, but differs in the truncate ligules, the smaller spikelets, and more strongly nerved empty glumes. It has the narrow inflorescence and narrow empty glumes of *P. nemoralis* and thereby differs from *P. interior*, which also has been confused with the European relative.

WYOMING: Big Horn Mountains, July, 1899, *F. Tweedy 2141*, (type, in herb. N. Y. Bot. Gard.); Gros Ventre River, Aug., 1897, *F. Tweedy 101*.

IDAHO: Northern Idaho, 1892, *J. H. Sandberg 373*.

Distichlis dentata sp. nov.

Perennial, with a creeping branched scaly rootstock; stem 1–3 dm. high, very leafy; leaf-blades 5–12 cm. long, 2–3.5 mm. wide, flat or slightly involute; panicle of the pistillate plant 4–8 cm. long, 2–2.5 cm. wide; spikelets 1–2 cm. long, 5–8 mm. wide, 7–17-flowered; empty glumes lanceolate, about 5 mm. long, short-acuminate, scarious-margined; floral glume ovate in lateral view, 6 mm. long, fully 2 mm. wide from keel to margin, short-acuminate; palet nearly as long, dentate on the keels; panicle of the staminate plant looser, 5–10 cm. long; spikelets more compressed, floral glumes lanceolate in lateral view, straw-colored, acute, thin.

This species differs from *D. spicata* and *D. stricta* in the broader leaves, larger and broader spikelets, larger and broader floral glumes and palets in the pistillate plant, and the distinct dentation on the keels of the latter. It has the broad leaves and the habit of *D. thalassica*, but lacks the loose sheaths of that species. The latter lacks the dentation of the palet characteristic of *D. dentata*.

WASHINGTON: 1893, *Sandberg & Leiberg 463* (♀, type, in herb. Columbia Univ.); Okanagon Valley, 1897, *Elmer 508* (♀.)

OREGON: Wild Horse Meadow, Southeastern Oregon, 1901, *Griffiths & Morris 504* (♂).

SASKATCHEWAN: Carlton House, *Richardson 28* (Franklin's Second Journ.).

NEVADA: Pleasant Valley, 1865, *Stretch 203* (♂); Carson, *248* (♀).

Festuca saximontana sp. nov.

? Festuca ovina pseudovina Beal, Grasses N. Am. **2**: 595. 1896.
Festuca pseudovina Rydb. Mem. N. Y. Bot. Gard. **1**: 56. 1900.

Not *F. pseudovina* Hack. 1880.

Festuca ovina pseudovina Piper, Contr. U. S. Nat. Herb. **10**: 26, 27. 1906. Not *F. ovina pseudovina* Hack. 1881.

Densely cespitose, perennial, with intravaginal innovations; stem 2–4 dm. high, slender, glabrous; basal leaf-sheaths short, closed only at the base, loose above; ligules very short and rounded; leaf-blades very slender, 3–10 cm. long, less than half a millimeter wide, strongly involute, in age becoming strongly striate; panicle very narrow and spike-like, 4–10 cm. long; its branches erect or nearly so, short; spikelets 4–6-flowered; first empty glume 1-nerved, about 2 mm. long, the second 3-nerved, 2.5 mm. long; floral glumes lanceolate, 3–5 mm. long, glabrous; awn 1–2 mm. long.

This species is rather common on dry hillsides and mountains from Saskatchewan to Colorado and British Columbia up to an altitude of 3600 m.

It has been mistaken for the European *F. pseudovina* Hackel. The latter was based on *F. ovina* Host, Gram. Aust. **2**: *pl. 84*. This plate does not at all represent our North American plant. The figure represents a small plant with a short open panicle, while our plant has a very narrow, rather long panicle with erect branches. Piper in his monograph (Contr. U. S. Nat. Herb. **10**: 27. 1905) cites Host's plate *no. 86*, instead of *no. 84*. Whether this is a mere misprint or whether Piper really had the former plate in mind, I do not know. Plate 86, representing *F. stricta*, illustrates a plant in habit much more like our plant. Whether Beal (Grasses N. Am. **2**: 595) had in mind the same plant as Piper and myself is very doubtful, as he cites only specimens from Michigan, and I have seen no specimens of *F. saximontana* from that state. As the type the following may be assigned:

ALBERTA: Vicinity of Banff, 1899, *W. C. MacCalla 2331* (type, in herb. N. Y. Bot. Gard.).

Festuca calligera (Piper) sp. nov.

Festuca amethystina asperrima Hack.; Beal, Grasses N. Am. **2**: 601. 1896. Not *F. asperrima* Link, 1822.

Festuca ovina calligera Piper, Contr. U. S. Nat. Herb. **10**: 27. 1906.

This I think is specifically distinct from *F. ovina*. In the herbaria at the New York Botanical Garden are found the following specimens:

ARIZONA: Southern slope of San Francisco Mountains, 1904, *Cannon & Lloyd;* Flagstaff, 1883, *Rusby 901* (dupl. of type); near Tucson, 1892, *Toumey.*

UTAH: Fish Lake Plateau, Aug. 9, 1905, *Rydberg & Carlton 7689* and *7680.*

COLORADO: Camp on Grizzly near foot of Rabbit Ear Range, State Agric. College distribution *no. 3649;* Breckenridge, 1896, *Shear 1080.*

Vulpia megalura (Nutt.) comb. nov.

Festuca megalura Nutt. Jour. Acad. Phila. II. **1**: 188. 1848.

The group of annual grasses with usually but one stamen, generally included in *Festuca,* is so unlike the typical species of that genus that it very well deserves generic rank. The genus *Vulpia* Nees should therefore be reëstablished.

Vulpia reflexa (Buckley) comb. nov.

Festuca reflexa Buckley, Proc. Acad. Phila. **1862**: 98. 1863.

Vulpia pacifica (Piper) comb. nov.

Festuca pacifica Piper, Contr. U. S. Nat. Herb. **10**: 12. 1906.

Vulpia octoflora (Walt.) comb. nov.

Festuca octoflora Walt. Fl. Car. 81. 1788.

Bromus Flodmanii sp. nov.

Bromus aleutensis Rydb. Mem. N. Y. Bot. Gard. **2**: 61. 1900.
Not *B. aleutensis* Trin. 1853.

A short-lived perennial; stem glabrous, 6–10 dm. high; sheaths retrorsely pilose; ligules 3–4 mm. long, laciniate; leaf-blades 2–3 dm. long, 6–10 mm. wide, minutely scabrous; panicle 1–2 dm. long; branches erect or nearly so; spikelets 2.5–3.5 cm. long, 5–7 mm. wide; empty glumes lanceolate in lateral view, about 1 cm. long, glabrous, acute, the first 3-nerved, the second 5-nerved; floral glumes about 15 mm. long, scabrous, narrowly margined, acuminate, slightly bifid; awn 4–6 mm. long; palet nearly as long as the floral glumes.

The first two specimens cited below were included in *B. marginatus latior* by Shear. He, however, has made on the sheet the following note: "very near *aleutensis,*" to which species the speci-

mens were originally referred. *B. Flodmanii* differs from *B. marginatus latior* in the scabrous, not pilose floral glumes, and the narrow inflorescence; from *B. aleutensis* it differs in the shorter awns, the smaller florets, and the less open inflorescence, and from *B. Hookerianus* in the smaller spikelets, shorter awns, and narrower scarious margins of the floral glumes. It agrees very well with the description and figure of *Ceratochloa breviaristata* Hook., but the palet is nearly as long as the floral glume.

MONTANA: Sheep Creek, Aug. 8, 1896, *J. H. Flodman 187* (type, in herb. N. Y. Bot. Gard.); same locality and date, *Rydberg 3308*.

UTAH: Mount Nebo, 1905, *Rydberg & Carlton 7595*.

WYOMING: Buffalo Fork, 1897, *F. Tweedy 65*.

Agropyron latiglume (Scribn. & Smith) sp. nov.

Agropyron violaceum latiglume Scribn. & Smith, U. S. Div. Agrost. Bull. **4**: 30. 1897.

Agropyron inerme (Scribn. & Smith) sp. nov.

Agropyron divergens inermis[*e*] Scribn. & Smith, U. S. Div. Agrost. Bull. **4**: 27. 1897.

Hordeum depressum (Scribn. &. Smith) sp. nov.

Hordeum nodosum depressum Scribn. & Smith, U. S. Div. Agrost. Bull. **4**: 24. 1897.

Elymus jejunus (Ramaley) sp. nov.

Elymus virginicus jejunus Ramaley, Minn. Bot. Stud. **1**: 114. 1894.

Elymus virginicus minor Vasey; Rydb. Contr. U. S. Nat. Herb. **3**: 193. 1895.

This was well described by Professor Ramaley. The description was overlooked when I a year later took up Dr. Vasey's manuscript name.

Elymus marginalis sp. nov.

Perennial, with a rootstock, somewhat tufted; stem 6–10 dm. high, glabrous or pubescent at the nodes; sheaths close, at least the lower ones retrorsely pilose; leaf-blades spreading, 1–2 dm.

long, 7–10 mm. wide, flat, scabrous beneath, usually pilose above; ligules almost obsolete; spike 1.5–2 dm. long; spikelets usually in pairs, 4–5 flowered; empty glumes 10–12 mm. long, narrowly lanceolate, scabrous on the 4 or 5 nerves, with white or pink scarious margins; floral glumes 10–12 mm. long, glabrous and shining; awns 8–20 mm. long.

This is closely related to *E. glaucus*, but differs in the glabrous floral glumes and the hairy sheaths and the hairy upper surface of the leaf-blades.

BRITISH COLUMBIA: Lower Arrow Lake, June 18, 1890, *Macoun 44* (type in herb. Columbia University).

WASHINGTON: Clallam, 1900, *Elmer 1905*.

Elymus Petersonii sp. nov.

Perennial, with a rootstock; stem 6–8 dm. high, slender, glabrous; sheaths glabrous, striate, shorter than the internodes; ligules very short and truncate; leaf-blades flaccid, 1–1.5 dm. long, 4–5 mm. wide, light green, minutely scabrous on the veins of both sides, or sparingly pilose above; spike very slender and lax; spikelets in pairs or single; empty glumes narrowly lanceolate, acuminate or awn-pointed, about 8 mm. long, 3-nerved, purple-tinged; floral glumes about 1 cm. long, glabrous; awn about 1 cm. long.

This species is also related to *E. glaucus*, but differs in the lax, interrupted spike, glabrous glumes, and the flaccid and more or less hairy leaf-blades.

BRITISH COLUMBIA: Roger's Pass, Selkirk Mountains, Aug. 9, 1904, *H. Peterson* [Shaw's distribution no.] *446* (type, in herb. N. Y. Bot. Gard.).

Elymus vulpinus sp. nov.

Perennial, with a short rootstock; stems 5–7 dm. high, striate, erect; sheaths close, striate, glabrous, often shorter than the internodes; ligule 1 mm. long or less, truncate, brown; spike exserted, 1–1.5 dm. long, 6–7 mm. thick, sometimes slightly nodding; spikelets 1 or 2 at each node, 4–6-flowered; empty glumes linear-lanceolate, 8–10 mm. long, 5-nerved, scabrous on the back; awn scabrous, of about the same length; floral glumes linear-lanceolate, long-acuminate, about 8 mm. long, hispidulous; awn 8–10 mm. long, scabrous.

This is one of the species connecting the genera *Elymus* and *Agropyron*. The type was originally named *Agropyron cani-*

num unilaterale (Cassidy) Vasey, which is the same as *A. Richardsonii*. J. G. Smith in his revision referred it to *A. Gmelini*. It resembles both a great deal in habit, but is distinguished by the hispidulous floral glumes and by the empty glumes, which are attached more or less obliquely, a character which would place the species in *Elymus* rather than in *Agropyron*. It is a close relative of *E. Saundersii* and *E. Macounii*, which also could be referred almost equally well to either genus. In habit *E. vulpinus* is intermediate between the two, but is distinguished by the hispidulous, instead of glabrous, floral glumes and broader empty glumes.

NEBRASKA: Lake region of Grant Co., northeast of Whitman, *Rydberg 1617* (type, in herb. N. Y. Bot. Gard.).

ALBERTA: Devil's Head Lake, Aug. 8, 1891, *Macoun 11452* in part, mixed with *Agropyron subvillosum* and named *A. dasystachyum*.

NEW YORK BOTANICAL GARDEN.

Helleborine Hill or Epipactis Adans.?

G. Claridge Druce

I first suggested the above change of names in the Annals of Scottish Nat. Hist. 48. 1905, because during my work at the herbaria of Morison and Dillenius I became saturated with pre-Linnean names and found how often and how needlessly Linnaeus had changed well-defined generic names. The above is an example. The *Helleborine* of Dioscorides has been attributed by various authors to different species, but the figure of the plant representing it in the plate 155 of the very rare copy of the Vienna Ms. from Constantinople, which we have at Oxford, appears to be *Asphodelus ramosus*. Turner (Herball 128. 1562) quotes Dioscorides under the name *Satyrion* for the British typical species (*H. latifolia*). Gerarde (Herball 358. 1597) describes three species; the first *Helleborine* refers to *H. latifolia*, the second is *Cephalanthera Damasonium*, and the third is probably *Helleborine palustris*. Parkinson (Theatrum 218. 1640) has eight Elleborines, one being *Cypripedium*, while Caspar Bauhin (Pinax 187. 1671) under *Helleborine* has ten species. These are mainly adopted by Ray (Historia Plantarum **2**: 1230. 1688), who describes *Helleborine* and distinguishes the genus by "Radice fibrosa foliis nervosis ab Orchide differt," and puts in it thirteen species, which include the plants more recently called *Epipactis*, *Cephalanthera*, and *Cypripedium*, but excludes those with tuberous roots called *Serapias* by Linnaeus, which Ray puts with *Orchis*.

In his Synopsis . . . Stirpium Britannicarum, 174. 1690, six species are included:

No. 1, being *H. latifolia* (All.) as of the Historia.

No. 2, which = no. 5 of the Historia = *H. atropurpurea* (Raf.).

No. 3, which = no. 6 of the Historia = *Cephalanthera Damasonium* (Mill.) and partly *C. longifolia*, so far as the Westmoreland locality is concerned.

No. 4, which = *C. longifolia* Fritsch.

No. 5, which = no. 10 of the Historia = *H. palustris* Schrank. (This was first recorded as British in Lobel's Illustrationes, 94 1655, as "Tertiae Clusii Helleborines similem facie. . . .")

No. 6, which = no. 12 of the Historia = *Cypripedium Calceolus* L.

In the second edition, 242, 1696, Ray inserts a new no. 4, "*Helleborine latifolio flore albo clauso* . . . Found by Dr. Eales near Digges-Well in Hartfordshire," which was identified by the authors of the flora of that county as *C. ensifolia*, but Mr. Britten says the plant representing Miller's *Serapias latifolia* based on this is *C. grandiflora*. Dillenius (in the third edition of the Synopsis 384. 1724) adds to the description of no. 4 "Eadem cum priore," but there is no specimen in his herbarium. Bobart (Plantarum Historia Universalis Oxoniensis 486. 1699) describes seventeen species, which, like those of Ray, contain no specimens of the restricted genus *Serapias*. Tournefort (Institutiones Rei Herbariae 1: 436) in 1700, under the name *Helleborine*, says "est plantae genus," describes it, and adds "His notis addendae sunt radices fibratae." Six species are given, three being species of *Cephalanthera*. Tournefort includes *Serapias* with *Orchis*, but keeps as distinct genera *Calceolus*, *Limodorum*, *Ophris* (which includes *Listera*, *Malaxis*, etc.) and *Nidus avis*, showing that despite the unwieldy nature of his genus *Orchis*, he really possessed a truer conception of the genera of Orchidaceae than did Linnaeus.

Therefore prior to Linnaeus (with the exception of Haller) we have practical unanimity among botanists in using the name *Helleborine* so as to exclude the tuberous-rooted species now known as *Serapias*. Unfortunately, Linnaeus (Species Plantarum, 1753) seeing that some of Tournefort's species of *Orchis* were generically distinct, established the genus *Serapias*, adding, wrongly, the various species of *Helleborine* of previous authors, a pernicious example unfortunately followed by more recent authors. A contemporary botanist, John Hill, of Denham, Bucks, a voluminous writer, who was much disliked by other British botanists, and whose volumes have for long remained ignored, published in 1756 the British Herbal. In this work Hill points out with great acumen the errors Linnaeus had made, describes the faulty characterization

of many of his genera, and shows clearly the differences which mark as distinct such genera as *Limonium* and *Statice*, *Valeriana* and *Valerianella*, *Linaria* and *Antirrhinum*, and *Trifolium* and *Melilotus*. This work has escaped the attention of non-British botanists, and from its not adopting the binomial system remained unquoted, even in the Index Kewensis. But from the description of the species and genera, the reference to other writers, as well as the engraved plates and its valid data of publication, it is available for citation of genera.* In the British Herbal Hill not only separates the genera given above, but also distinguishes *Centaurium* from *Gentiana*, *Glaucium* from *Papaver*, *Polygonatum* from *Convallaria*, *Radiola* from *Linum*, *Nymphoides* from *Menyanthes*, *Onobrychis* from *Hedysarum*, *Foeniculum* from *Anethum*, *Petasites* from *Tussilago*, *Oxyria* from *Rumex*, *Damasonium* from *Alisma*, *Phyllitis* from *Asplenium*, *Meum* from *Athamanta*, *Alnus* from *Betula*, *Castanea* from *Fagus*, *Cirsium* from *Carduus*, *Oxycoccus* from *Vaccinium*, *Pneumaria* from *Pulmonaria*, *Cammarum* from *Helleborus*, *Radicula* from *Sisymbrium*, *Lens* from *Ervum*, and, as we shall see, *Helleborine* from *Serapias*, genera which had been wrongly united by Linnaeus.

In the British Herbal, 477, Hill defines *Helleborine* so as to exclude *Serapias Lingua* (itself a composite species), as described by Linnaeus, practically in this following Ray and Tournefort, but excluding *Cypripedium*. Hill goes on to say "Linnaeus places this among the *Gynandria decandria*, the filaments being two and inserted in the pistil. He takes away the received name and calls it *Serapias*." We have thus in Hill's description a proper definition of Tournefort's genus made more accurate by the exclusion of *Cypripedium*, and limited to the true *Helleborine*, and the plants afterwards separated by Richard as *Cephalanthera*. Of the six species described by Hill five are cited from Caspar Bauhin and one (*Cephalanthera longifolia*) from Ray's Historia. Unfortunately, Adanson (Familles des Plantes **2**: 70. 1763) established (what has been called a genus) *Epipactis;* he separates no new genus

* In passing, one may say if Thellung (Bull. Herb. Boiss. II. **8**: 778. 1908) is correct in quoting Garsault for specific names, Hill is also available and has undoubted priority, but as the binomials used by both authors are accidental, it is wiser to ignore them.

apart from *Serapias*, as understood by Linnaeus, but, on the contrary, adds vastly and most unscientifically to it. His description, compared with that of Hill, is quite indefinite, covering as it does *Serapias*, *Helleborine*, *Cypripedium*, *Pogonia*, and many other genera, as is shown by his synonymy in the erratic table or index (**2** : 554); it is a rubbish-heap rather than a properly formulated genus and is wisely to be ignored. It may, however, be contended that *Epipactis* as established by Crantz (Stirpes Austriacum 456. 1769) is available. This author writes *Epipactis* Haller, giving also synonyms "*Ophrys*, *Nidus avis*, *Helleborine* Tourn. aliorum, *Ophrys*, *Serapias*, *Neottia*, *Herminium* Linn.," but his definitions do not separate *Serapias* from *Helleborine*, indeed, as the synonyms quoted show, it is meant to cover both. The first and second species of his *Epipactis* are Cephalantheras; others included belong to the genera *Goodyera*, *Listera*, *Spiranthes*, *Neottia*, and *Helleborine*, eight different genera in all being included in this extraordinary group, which is scarcely less inchoate than that of Adanson. Doubtless, if *Serapias* grew in that portion of Austria treated of by Crantz, that also would have been included. *Epipactis* is however rendered invalid by Boehmer's restoration of Haller's genus *Epipactis* established in 1741 (Stirpes Helv. 277) and adopted by Allione in the Flora Pedemontana, to define the plant more recently known as *Goodyera*, as his description and synonyms clearly show. It is true Haller subsequently lost grip of its characters and added many other plants, some even generically different species, to his original *Epipactis*, but this was done in works published before 1753 and are therefore not valid for citation.

The publication in 1805 by Willdenow of his edition of the Species Plantarum in which he followed Swartz (Act. Holm. 231. 1805) in using the name *Epipactis* to represent *Helleborine*, *Cephalanthera*, *Listera*, *Neottia*, etc., led Brown (Aiton, Hort. Kew. **5**: 201. 1813), Gray (Nat. Arr. Brit. Pl. **2**: 212. 1821), and Smith (English Flora **4**: 40. 1828) to adopt that name, which has been in general use since that time.

It being thus evident that Hill's genus *Helleborine* must supersede *Epipactis* Adans., the species will stand as follows:

Helleborine africana (Rendle, Jour. Bot. **33**: 252. 1895, as *Epipactis*).

H. atropurpurea (Raf. Car. 87. 1810, as *Epipactis*).

= *Serapias atrorubens* Hoffm. Deutsch. Fl. **1**[2]: 182. 1804, as a subspecies.

H. babianifolia (Roxb. Hort. Bengal. 63, as *Epipactis*).

H. consimilis (Wallich, Cat. no. 7403, as *Epipactis*).

H. gigantea (Dougl.; Hook. Fl. Bor.-Am. **2**: 202, as *Epipactis*).

= *Epipactis Royleana* Lindl. in Royle, Illust. Bot. Himal. 368.

H. LATIFOLIA Druce *vice Epipactis latifolia* All.

H. microphylla (Sieb. Sv. Vet.-Akad. Nya Handl. 232. 1800, as *Epipactis*).

H. orbicularis (C. Richt. Verh. Zool.-Bot. Ges. Wien **37**: 190. 1887, as *Epipactis*).

H. PALUSTRIS Schrank, Fl. Monac. **2**: 190. 1814.

= *H. longifolia* Rendle, Jour. Bot. **45**: 441. 1907.

H. papillosa (Franch. & Sav. Enum. Pl. Jap. **2**: 519. 1879, as *Epipactis*).

H. pycnostachys (C. Koch, Linnaea **22**: 289. 1849, as *Epipactis*).

H. somaliensis (Rolfe in Fl. Trop. Afr. **7**: 189. 1897, as *Epipactis*).

H. Thunbergii (A. Gray in Perry Exp. Jap. **2**: 319. 1857, as *Epipactis*).

H. trinervia (Roxb. Fl. Ind. **3**: 455. 1832, as *Epipactis*).

It will be observed that I have followed all the recent British and most continental authorities in keeping distinct the two genera *Cephalanthera* and *Helleborine* (*Epipactis* R. Br. not Boehmer), thus differing from A. A. Eaton (Proc. Biol. Soc. Washington **21**: 63–68. 21 Mr 1908), who follows Wettstein in uniting them.

Mr. Eaton is quite correct in stating that Linnaeus' genus *Serapias* is composite — so too are his species. But since Hill in 1756 first separated *Helleborine* from that composite genus, leaving *Serapias* as understood by Swartz, and restored the name which for centuries previously had been used, his genus has priority according to the Vienna Rules. Hill's genus, it is true, included *Cephalanthera*, subsequently separated by Richard; but even if Wettstein be correct in uniting them, the application of the name

Helleborine to the whole group would not be invalidated, and the plants more recently called *Cephalanthera* would have to be termed *Helleborine*. To attempt to restrict the name *Serapias* to species of *Cephalanthera* and *Epipactis* is contrary to both the first and second editions of the Species Plantarum.

OXFORD, ENGLAND.

A new species of Puccinia

R. E. Stone

The genus *Puccinia* has so many species and so many of them are so hard to determine that it seems almost an imposition to describe a new species. However, in collecting, something is occasionally found that can not be referred correctly to any known species.

The "rusts" on plants of the Cyperaceae most frequently belong to the genus *Puccinia*. However, *Rynchospora* seems to be an exception and the only "rust" I find listed for

FIGURE 1. *P. angustata* Peck. II and III, × 260.

Notice the position and character of the germ-pores of the urediniospores.

that genus belongs to the *Uromyces* type of the Uredineae. For this reason, when I discovered on *Rynchospora corniculata* (Lam.) A. Gray, a *Puccinia*, I immediately began to try to find some place for it among the species recorded on the various Cyperaceae. After careful comparisons this species of *Puccinia* was found to agree fairly well with *Puccinia angustata* Peck but differs from it sufficiently to warrant its description as a new species.

Puccinia angustatoides sp. nov.

O et I. Incognatis.

II. Urediniosoris hypophyllis, minutis, linearibus, 0.5–1 mm.,

cinnamomeo-brunneis, pulverulentis, sparsis, epidermide diu tectis. Urediniosporis subglobosis v. obovoideis, echinulatis, ferrugineo-brunneis, 19–22 μ × 10–17 μ, poris germinationis 2 supra aequetorem praeditis.

III. Teliosoris hypophyllis, atro-brunneis, linearibus, 0.5–1.5 mm., sparsis, epidermide tectis. Teliosporis castaneo-brunneis, in-

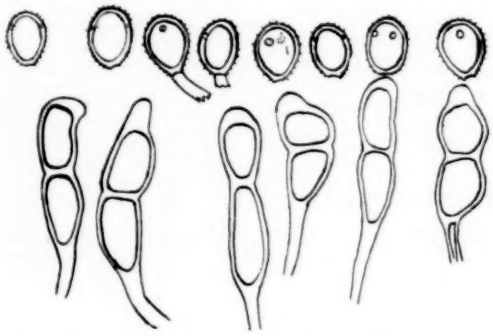

FIGURE 2. *P. angustatoides.* II and III, × 260.

The figures show more difference in the teliospores than usually exists. The urediniospores are very characteristic, as is also the position of the germ-pores.

aequalibus, clavatis, 40–70 μ × 15–26 μ, medio constrictis, apice valde incrassatis 5–10 μ, obtusis v. acuminatis; pedicello persistente, brunneo, 19–40 μ.

O et I. Incognatis.

II et III. In vivis foliis *Rynchosporae corniculatae* (Lam.) A.

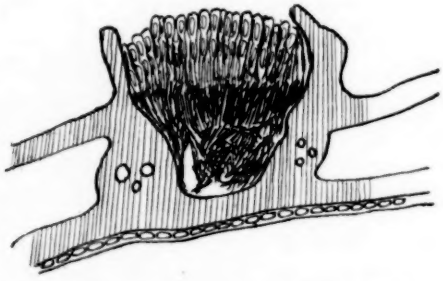

FIGURE 3. Section through a sorus of *P. angustata* Peck, as found on *Scirpus atrovirens*, × 80. The mass of hyphae in the lower part is very characteristic.

Gray, Auburn, Alabama, Sept. 17, 1908, *R. E. Stone.*

III. Auburn, Alabama, Jan. 1, 1909, *E. E. Binford.*

This rust has a close resemblance to *P. angustata* Peck on *Scirpus atrovirens*. The teliospores are of about the same size and shape and have the same position on the leaf. However the sori are more scattered, a little lighter in color and do not become confluent. The most prominent difference between the telia becomes apparent upon examining a section through a sorus. In all the specimens of *P. angustata* which I have been able to secure, there is a very prominent development of the hyphae in the large intercellular spaces of the leaf, especially immediately under a sorus. In fact the very large intercellular space between the vascular bundles is almost filled with hyphae. In *P. angustatoides* this development is much less pronounced, although the space between the vascular bundles is filled with stellate cells and would, apparently, offer a much better chance for the hyphae to develop. In studying the fungus this was the first thing to become apparent. Also, the telia are much more deeply sunken in *P. angustata* Peck.

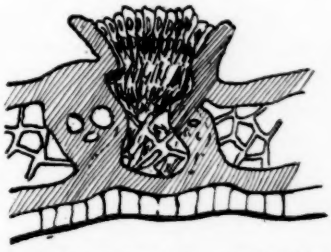

FIGURE 4. Section through a sorus of *P. angustatoides* on *Rynchospora corniculata*, × 80. This sorus is more superficial in every way than that of *P. angustata*.

The most distinctive difference between these two rusts is found in the uredinia and urediniospores. The uredinia in *P. angustatoides* are a little darker than in *P. angustata*, are more definite, scattered, rarely confluent. The urediniospores of *P. angustatoides* are several μ smaller than those of *P. angustata*, 19–22 μ × 10–17 μ as against 21–30 μ × 16–21 μ; they are subglobose to obovoid as against globose to elliptical in *P. angustata*. The last point of difference lies in the distribution of the germpores. In *P. angustata* the pores are 2, opposite and approximately equatorial; in *P. angustatoides* they are considerably above the equator, at least half way to the distal end of the spore, two in number and without a prominent thickening of the wall.

The accompanying figures show the most prominent differences.

Type specimens gathered by R. E. Stone, at Auburn, Alabama, Sept. 17, 1908, on *Rynchospora corniculata* (Lam.) A. Gray, deposited in the herbarium of the University of Nebraska.

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INDEX TO AMERICAN BOTANICAL LITERATURE

(1909)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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